

LOWER CRETACEOUS AMMONITES FROM NORTH-EAST ENGLAND : THE HAUTERIVIAN GENUS *SIMBIRSKITES*

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SYNOPSIS

Simbirskites (with four subgenera, *Simbirskites* s.s., *Speetonicer*as, *Milanowskia* and *Craspedodiscus*) occurs in Beds C7-LB5 of the Speeton Clay of Filey Bay, Yorkshire, and in the Lower Tealby Clay and Tealby Limestone of Lincolnshire. The stratigraphy of these beds is outlined and 21 species of *Simbirskites* occurring therein are described. 2 species, *S. (C.) juddi* and *S. (C.) variabilis*, are new, 14 are referred to or compared with previously described species, and 5 are left under open nomenclature. The occurrence of the ammonite genera *Aegocrioceras*, *Crioceratites*, *Paracrioceras*, *Protaconeceras*, *Spitidiscus*, *Hypophylloceras* and *Lytoce*ras in the *Simbirskites* beds is reviewed. As a result of careful bed-by-bed collecting of the ammonite fauna the *Simbirskites* beds of the Speeton Clay have been divided into five zones, all defined by species of *Simbirskites*. This new zonation replaces earlier schemes proposed by Spath (1924) and Chernova (1951). The faunal succession now established allows a detailed comparison to be made with the equivalent beds in Russia and north Germany. The problem of correlating the Hauterivian-Barremian boundary of the standard Tethyan sequence with the north European succession is briefly discussed with reference to the well-known occurrence in the northern Caucasus and Crimea of a mixed Boreal (*Simbirskites*)—Tethyan fauna.

I. INTRODUCTION

Simbirskites occurs in the Hauterivian beds of the Boreal Province and is a useful zonal form in Russia, north Germany and north-east England. The ammonite fauna of the Russian *Simbirskitid* Beds consists almost exclusively of species of this genus, whereas the corresponding beds in Germany and England yield a more varied fauna with crioceratitid ammonites common at some horizons. Hence different zonal schemes have evolved, the German (Koenen 1902, Stolley 1925) and north-west European (Spath 1924) zonations utilizing a combination of *Simbirskites* and crioceratitid and holcodiscid ammonites as zonal forms while the Russian scheme (Pavlow 1901, Chernova 1951) relies exclusively on *Simbirskites*. The differences between the various zonations obscure the close similarity that exists between the *Simbirskites* faunas of the three areas.

The first species of *Simbirskites* to be described were the Speeton Clay "*Ammonites*" *speetonensis* (Young and Bird 1828) and "*A.*" *concinus*, "*A.*" *marginatus* and "*A.*" *venustus* (Phillips 1829), but most of the early descriptive work was published in Germany (e.g. Roemer 1841, Neumayr and Uhlig 1881, Weerth 1884) and Russia (e.g. Trautschold 1865, Lahusen 1874, M. Pavlow 1886, A. P. Pavlow 1901). Many of the German type and figured specimens have subsequently been lost or destroyed.

The English fauna has never been described in detail, though *Simbirskites* is quite common in the Speeton Clay (beds C7-LB5) of Yorkshire and also occurs in the Lower Tealby Clay and Tealby Limestone of Lincolnshire. A few species have been figured by Pavlow (1889), Pavlow *in* Pavlow and Lamplugh (1892) and Danford (1906), and individual records have been discussed by Judd (1867, 1868, 1870) and Lamplugh (1889, 1896). The standard reference on the Speeton ammonite sequence is Spath's (1924) exhaustive faunal list which recorded over 20 *Simbirskites* species.

The present review of the English fauna is based on material collected bed by bed by the author, supplemented where necessary by museum material. Most of the museum specimens are poorly localized and reference is made therefore only to particularly important specimens. The author's collection has been divided between the British Museum (Natural History) and the Department of Geology, University of Hull.

This paper forms part of a study commenced during the tenure of an N.E.R.C. Research Studentship in the University of Hull (1963-66) and continued during the tenure of an N.E.R.C. Post-Doctoral Fellowship at Queen Mary College, University of London (1966-67). Field work in Germany was assisted by a grant from the British Council under the Younger Research Workers Interchange Scheme (1965) and an award from the Daniel Pidgeon Fund of the Geological Society of London (1969). I gratefully acknowledge an award from the Central Research Fund of the University of London.

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II. STRATIGRAPHY

(a) *The Speeton Clay*

The type-locality of the Speeton Clay is a 1.2 kilometre ($\frac{3}{4}$ mile) coastal section along the southern part of Filey Bay, Yorkshire (Text-fig. 1). Here the clay crops out in low cliffs, where the succession is frequently obscured by slipped or rain-washed material. Hence the section often appears as "a wild and tumbled slope of clay in which at first sight it is hopeless to make out any order" (Blake 1891 : 138). Occasionally, however, the sea reaches the cliff face and cleans parts of the section, or sand may be removed from the beach in the intertidal zone to give continuous exposures of the underlying clays. Such transient exposures allow one to build up a composite picture of the Speeton succession, though some parts are still poorly known.

Leckenby (1859) and Judd (1868) made the first serious attempts to subdivide the Speeton Clay, but the classic description, and the one upon which all subsequent work has been based, is that of Lamplugh (1889). On the basis of the belemnite sequence Lamplugh recognized four major divisions, labelled A-D from the top

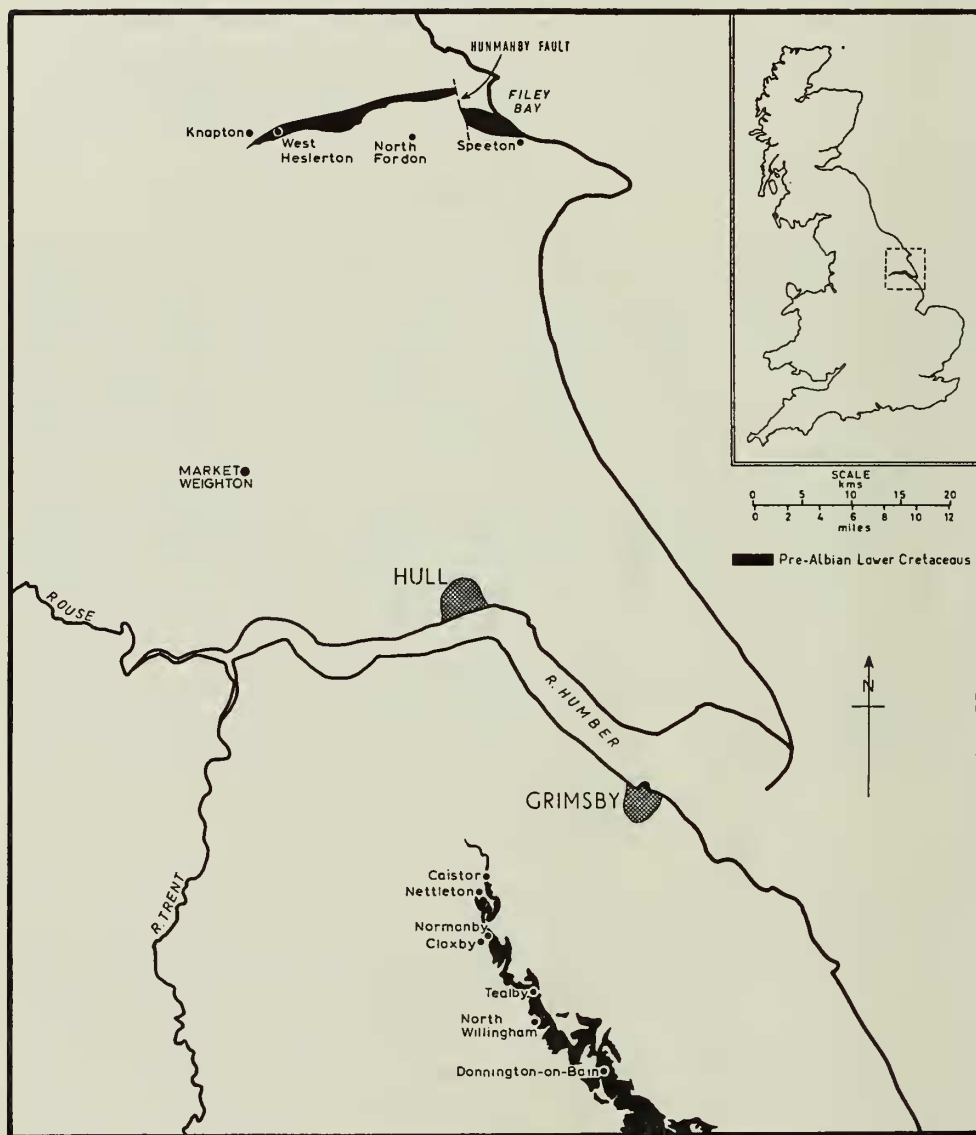


FIG. 1. Map showing the distribution of pre-Albian Lower Cretaceous rocks in East Yorkshire and North Lincolnshire, and the localities mentioned in the text.

downward (the reverse of the normal stratigraphical procedure). A fifth division, bed E, is a 100 mm (4 inch) thick seam of phosphatic nodules, the "Coprolite Bed", which rests on Upper Kimmeridge Clay.

Lamplugh further divided each of his major divisions; thus the B Beds were divided into Upper B, the Cement Beds and Lower B, and the C Beds into C_I to C_{II}. These subdivisions provided the framework for a more detailed subdivision (based on lithological changes) of the Lower B Beds by Kaye (1964) and of the C Beds by Fletcher (1969). *Simbirskites* first appears in C₇H (the lowest subdivision of bed C₇) and the last known specimens are from LB₅E, only 0.61 metres (2') above the base of Lower B. All the author's specimens have been localized according to Fletcher's and Kaye's bed numbers. The succession below is essentially that of Fletcher and Kaye, with only minor amendments, and their bed numbers are followed throughout.

SUCCESSION:	metres	ft.	in.
LB ₅ D Dark, often shaly, pyritic clay with 75 mm (3") mottled band (light mottles in dark clay) at top	0.91	3	0
LB ₅ E Dark, highly glauconitic mottled clay	0.46	1	6
LB ₆ Pale blue clay, weathering brown, with occasional "potato stone" nodules. Top 75 mm (3") mottled (dark mottles in light clay)	0.51	1	9
C ₁ A Dark, glauconitic clay with conspicuous pale mottling	0.13		5
C ₁ B Pale grey clay mottled by large, dark, glauconitic streaks	0.10		4
C ₂ A Dark grey glauconitic clay with large pyrite crystals	0.30	1	0
C ₂ B Pale grey clay, darker in lowest 75-100 mm (3-4"). Band of small (25-50 mm), brown-weathering calcareous nodules at base	0.30	1	0
C ₂ C Medium grey clay becoming paler downwards	0.76	2	6
C ₂ D Dark, gritty, glauconitic clay with pale streaks. Stands out as a thin but prominent dark band among the lighter clays above and below	0.10		4
C ₂ E Pale grey clay; brown-weathering streak with occasional calcareous nodules in upper part	0.46	1	6
C ₂ F Medium grey clay. Boundary between this and C ₃ is gradational	0.61	2	0
C ₃ (The " <i>Echinospatangus</i> Bed" of Lamplugh) Pale grey clay with a conspicuous layer of sparsely scattered, brown-weathering calcareous nodules (up to 150 mm diameter) 0.9 m (3') above the base	2.44	8	0

SUCCESSION:		metres	ft.	in.
C4A	Thin limestone band, pale grey-green when fresh but weathering a pale reddish-purple; forms a good marker horizon for the top of C4	0.07	3	
C4B	Dark, glauconitic clay	0.76	2	6
C4C	Pale clay with small phosphatic nodules	0.61	2	0
	Mottled bed; light mottles in dark glauconitic clay	0.15		6
	Pale clay	0.15		6
C4D	Thin, greenish-yellow impure limestone. Very similar to bed C4A	0.07	3	
C4E	Dark grey glauconitic clay	0.30	1	0
C4F	Pale grey clay	0.46	1	6
C4G	Dark grey clay, mottled at top (large pale streaks in dark clay)	0.46	1	6
C4H	Brown weathering silty clay with occasional round calcareous nodules (up to 150 mm in diameter)	0.23		9
C4I	Dark, shaly clays	3.05	10	0
C4J	Brown-weathering silty clay with small, slightly flattened brown calcareous nodules at base	0.23		9
C4K	Dark grey clays, glauconitic in middle	2.70	9	0
C4L	Brown weathering silty band, without nodules but patchily indurated. Large <i>Simbirskites</i> (<i>Craspedodiscus</i>) <i>gottschei</i> and <i>Aegocrioceras</i> cf. <i>seeleyi</i>	0.23		9
C5A	Dark grey clays with thin mottled band at top	1.52	5	0
C5B	Olive grey clay with large, light coloured mottles at base	0.46	1	6
C5C	Dark grey clay with occasional small brown nodules	0.91	3	0
C5D	Dark grey clay with pyrite; finely mottled bed near top	0.76	2	6
C5E	Pale green, slightly glauconitic clay with occasional nodules	0.23		9
C5F	Dark grey clays with large pale mottles near top; bed of small nodules in middle	0.91	3	0
C5G	Brown-weathering silty clay, partially indurated, and with widely scattered, large calcareous nodules	0.23		9
C5H	Medium grey clay	0.76	2	6
C5I	Pale grey clay	0.15		6
C5J	Olive grey clay, mottled in part (light mottles in darker clay)	0.46	1	6

SUCCESSION:		metres	ft.	in.
C5K	Dark grey clay with some pyrite; occasional small brown nodules	1.70	5	6
C5L	Brown-weathering silty clay, partially indurated and with widely scattered calcareous nodules	0.23	9	
C6	Dark grey shaly clays with 75 mm (3") mottled bed at top (large and small pale grey mottles in dark clay). Occasional brown nodules in upper portion. Small <i>Simbirskites</i> (<i>Milanowskia</i>) <i>concinus</i> common in lowest 0.61 m (2')	4.55	15	0
C7A	Brown-weathering, silty indurated clays with large calcareous nodules. Large <i>Crioceratites</i> common	0.30	1	0
C7B	Pale grey clay	0.30	1	0
C7C	Dark grey clay with large mottling (pale mottles in dark clay) at top	0.38	1	3
C7D	Pale grey clay with a little glauconite	0.30	1	0
C7E	Black clay; large pale grey mottles at top. Glauconite abundant in upper part of clay, decreasing downward and absent at base	0.38	1	3
C7F	{ Pale grey clay with abundant flattened impressions of <i>Simbirskites</i> (<i>Speetoniceras</i>) sp.	0.15	6	
	{ Pale grey silty clay, weathering brown and locally indurated. Contains rounded phosphatized nodules (up to 150 mm diameter) and larger, more irregular calcareous concretions. Body chambers of <i>Aegocrioceras</i> common	0.23	9	
	{ Pale grey clay, mottled in part. <i>Aegocrioceras bicarinatum</i> common	0.53	1	9
C7G				
C7H	Dark grey clay with abundant glauconite. Small <i>Simbirskites</i> (<i>Speetoniceras</i>) <i>inversum</i> and crushed <i>Thracia phillipsi</i> common.	0.30	1	0
C8	{ Pale grey clay with large (up to 100 mm diameter) nodules	0.23	9	
	{ Dark grey clay with bed of small (20 mm), brown-weathering nodules in middle. <i>Endemoceras regale</i>	1.80	6	0

Beds C8, C7 and the base of C6 are well exposed in the southern part of Middle Cliff, while the high C Beds (C4B to C1) and Lower B are seen in the cliff and adjacent parts of the foreshore at Black Cliff slip (opposite a breakwater at TA 151763) and also along a low cliff immediately north of Speeton Beck (for all localities on this section see map in Kaye 1964, figs 5 and 6). C4, C5 and most of C6 are seen only on

temporary beach exposures; C₄ and C₅ in particular are rarely clearly exposed, but from occasional observation and from published records both appear to be sparsely fossiliferous.

Although the succession is essentially argillaceous it is by no means monotonous; well-marked nodule bands, alternating pale and dark clays, gritty glauconitic beds, and bioturbated horizons (the "mottled beds") provide a series of useful marker horizons. In particular the brown-weathering, silty clays of C₄H, C₄J, C₄L, C₅G, C₅L, and C₇A are more resistant to erosion than the surrounding clays and stand out as slight but noticeable scars on beach exposures.

The Speeton Clay crops out inland along the southern edge of the Vale of Pickering, at the foot of the wold scarp, finally disappearing in the vicinity of Knapton (Text-fig. 1). The C and Lower B beds have never been exposed but have been proved in boreholes at North Fordon (Neale 1960 : 203) and West Heslerton (Neale and Sarjeant 1962 : 439).

(b) *The Tealby Beds*

The Lower Cretaceous deposits of the Lincolnshire-North Norfolk basin consist of a series of shallow-water ironstones, sandstones, limestones and clays. They thin southward towards the London Platform and northward towards the Market Weighton Upwarp, both of which were landmasses in pre-Albian Lower Cretaceous times.

The Tealby Beds, which form the middle part of the Lincolnshire succession, are subdivided into the Lower Tealby Clay, the Tealby Limestone and the Upper Tealby Clay. Ammonites are rare, but *Simbirskites* occurs in the Lower Tealby Clay and the Tealby Limestone. At present, the only good exposures of these beds occur at Nettleton, in north Lincolnshire, where they have been exposed during the quarrying of the underlying Claxby Ironstone. The correlation between the Lower Cretaceous succession here and the Speeton Clay has been summarized in Penny and Rawson (1969 : 212, table 1). The Lower Tealby Clay was formerly well exposed in the brick-yard next to Donnington-on-Bain station and the Tealby Limestone in numerous shallow pits around Tealby, Normanby and North Willingham.

1. *The Lower Tealby Clay*

The Lower Tealby Clay is generally a fairly uniform, stiff blue-grey clay with phosphatic nodules and prominent glauconitic streaks. *Hibolites jaculoides*, index belemnite of the C Beds of the Speeton Clay, occurs throughout, and this and rare ammonites together indicate a correlation with beds C₁ to C₇. There appears to have been a break in deposition between the Claxby Ironstone and the Lower Tealby Clay, for the former yields ammonites and belemnites typical of the upper D Beds of the Speeton Clay. The *regale* zone (C₈-C₁₁) is unrepresented in Lincolnshire, a faunal break first commented on by Lamplugh (1896 : 203).

Above the ironstone quarries in Nettleton Valley (TF 118985) the Lower Tealby Clay is about 12 metres (about 40 feet) thick. Partially phosphatized nodules in the basal 0.61 metres (2 feet) have yielded fragments of *Aegocrioceras* cf. *bicarinatum* (Young and Bird), a species common just above the base of C7 (C7G) at Speeton. The only *Simbirskites* from this locality have been found loose on tip heaps; they include a specimen close to *S. (M.) polivnensis* (p. 69), a crushed specimen of the *S. (M.) concinnus* group, and a whorl fragment of *S. (S.)* cf. *virgifer*, though the last may have come from the Tealby Limestone.

Elsewhere, *Simbirskites* has only been recorded from the old brick-pit at Donnington-on-Bain, where the record of "*Ammonites*" *speetonensis* (including "vars." *venustus* and *concinnus*) (Ussher, Jukes-Brown and Strahan 1888 : 97) suggests the *speetonensis* zone. "*Crioceras duvalii*" (probably a *Crioceratites* of the *wermbleri* group) indicates a similar or slightly earlier (top *inversum* zone) horizon, while Lamplugh's (1896 : 207) record of "*Olcostephanus (Simbirskites) umbonatus*" (figured by Pavlow (1892), and discussed below under *S. (S.) yorkshirensis*) from the same pit suggests that a higher horizon (early *variabilis* zone) is also represented.

2. The Tealby Limestone

The Tealby Limestone consists of a series of thin, impure arenaceous limestones interbedded with oolitic clays. It reaches its maximum thickness of 6 metres (20') in Nettleton Valley, and forms a prominent scarp feature from Caistor to Donnington-on-Bain. Further south the individual limestones become thinner and softer and no longer form a noticeable ridge, until in south-east Lincolnshire the Tealby Limestone is virtually indistinguishable from the Lower and Upper Tealby Clays.

Belemnites (*Oxyteuthis pugio* and allies) indicate a correlation with the B Beds of the Speeton Clay, and the rare ammonites suggest a correlation with the lower part of Lower B; the only ammonite common to both beds is *Simbirskites (Craspedodiscus) discofalcatus* which occurs in Bed LB6 at Speeton. The ammonites described below (*S. (C.) juddi*, *S. (C.) discofalcatus* and *S. (?C.)* sp. b) were collected in the last century at a time when the numerous shallow pits between Normanby and North Willingham and around Tealby were being worked by hand. Details of some of the exposures have been given in Judd (1867 : 244) and Lamplugh (1896 : 209). Although the present exposures in Nettleton Valley are good the limestone is now removed mechanically and the workmen very rarely collect ammonites. A single, poorly preserved, indeterminate *S. (Craspedodiscus)* has been collected by the author.

Spath's (1924 : 79, 82) anomalous record of *S. aff. toensbergensis* (Weerth) and *S. aff. fasciatofalcatus* (Lahusen) from the Claxby Ironstone of Claxby led him to tentatively correlate the upper part of the ironstone with C4 of the Speeton Clay. The two specimens are in the Sedgwick Museum, numbers B11122 and B11123 respectively; their preservation shows that the former (an indeterminate species) came from the Tealby Limestone or Lower Tealby Clay and the latter (discussed below as *S. (C.) discofalcatus*) from the Tealby Limestone.

III. THE ASSOCIATED AMMONITE FAUNA

Representatives of five other ammonite families, the Crioceratitidae, Holcodiscidae, Oppeliidae, Phylloceratidae and Lytoceratidae are associated with *Simbirskites* in beds C7–LB5 of the Speeton Clay; only the Crioceratitidae are common. The rare oppeliid genus *Protaconeceras* is represented by an undescribed species from C4 (Casey 1954 : 270) and the holcodiscid *Spitidiscus rotula* (Sowerby) occurs in the lower part of C5 (C5L). A related form, *S. inflatiformis* Spath, occurs in the nodule bed at the top of C8. A whorl fragment (author's colln., BM. C.75852) of the phylloceratid *Hypophylloceras* cf. *perlobatum* (Sayn), previously known from Speeton by a single specimen from C8 (Rawson 1966 : 455), has been found about 0.60 metres (approximately 2 feet) above the base of C6. From slightly higher in C6 (about 1.8 metres above the base) Whitehouse and Brighton (1924 : 360) recorded *Lytoceras* cf. *subfimbriatum* (d'Orb.).

The Crioceratitidae first appear in bed C7G, just above the base of C7, and occur through the overlying Upper Hauterivian and Barremian beds of the Speeton section. Numerous species of *Aegocrioceras* occur in bed C7 (Spath 1924, Rawson 1970) and *Crioceratites* is common in C7A and lower C6. Higher in the C Beds section crioceratitids are rare; large body chamber fragments of *Aegocrioceras* cf. *seeleyi* (Neumayr and Uhlig) occur in C4L and two small, septate whorl fragments of *Paracrioceras statheri* Spath have been collected in bed C2C.

In Lincolnshire, *Aegocrioceras* and *Crioceratites* occur in the Lower Tealby Clay (p. 35) and poorly preserved crioceratitids in the Tealby Limestone. A single *Lytoceras* aff. *vogdti* Karakasch is recorded from the latter bed (Spath 1924 : 79).

IV. SYSTEMATIC DESCRIPTIONS

Morphological terms used in the systematic descriptions are defined in the ammonoid volume of the "Treatise on Invertebrate Paleontology" (1957 : R. C. Moore, editor). Detailed ontogenetic studies of sutural development are beyond the scope of this paper, and for the purposes of general morphological description of representative suture lines the relatively simple terminology used in the "Treatise" (Moore 1957 : L96, fig. 141) has been followed.

Dimensions are given in millimetres, as follows: diameter; oblique whorl height, whorl thickness, width of umbilicus.

The oblique whorl height is measured from the mid-line of the venter to the umbilical seam, and the whorl thickness has been measured on the ribs and not between.

The specific descriptions are based on 227 specimens from Speeton and Lincolnshire, together with a limited number of foreign specimens (12 German and 5 Russian) which are referred to for comparative purposes. The 244 specimens are distributed among 23 discrete taxa, as follows:

	Speeton	Lincolnshire	Germany	Russia
<i>S. (Sp.) subbipliciforme</i>	7	—	—	—
<i>S. (Sp.) inversum</i>	29	—	—	2

	Speeton	Lincolnshire	Germany	Russia
<i>S. (Sp.) cf. versicolor</i>	2	—	—	—
<i>S. (Sp.) sp.</i>	1	—	—	—
<i>S. (M.) concinnus</i>	66	—	1	—
<i>S. (M.) speetonensis</i>	22	—	—	1
<i>S. (M.) sp.</i>	3	—	1	—
<i>S. (M.) staffi</i>	2	—	2	—
<i>S. (M.) lippiacus</i> and <i>S. (M.) cf. lippiacus</i>	4	—	2	—
<i>S. (C.) gottschei</i>	8	—	2	—
<i>S. (C.) cf. kayseri</i>	3	—	1	—
<i>S. (C.) variabilis</i>	12	—	—	—
<i>S. (C.) discofalcatus</i> and <i>S. (C.) cf. discofalcatus</i>	6	7	—	1
<i>S. (C.) phillipsi</i>	—	—	2	—
<i>S. (C.) sp. (phillipsi group)</i>	3	—	—	—
<i>S. (C.) juddi</i>	—	2	—	—
<i>S. (?C.) sp. a</i>	14	—	—	—
<i>S. (?C.) sp. b.</i>	—	1	—	—
<i>S. (S.) umbonatus</i>	—	—	—	1
<i>S. (S.) marginatus</i>	13	—	—	—
<i>S. (S.) yorkshirensis</i> and <i>S. (S.) cf. yorkshirensis</i>	5	1	—	—
<i>S. (S.) decheni</i> group	15	—	1	—
<i>S. (S.) cf. virgifer</i>	—	1	—	—
	215	12	12	5

In addition, reference is made at the end of this section to a number of specimens which are too inadequately preserved for accurate determination.

Abbreviations: BM. = British Museum (Natural History); GSM. = Geological Survey Museum; Göttingen = Geologisches-Palaeontologisches Institut, Georg-August-Universität, Göttingen; NLFb = Niedersächsisches Landesamt für Bodenforschung, Hannover; HU. Rn. = Rawson collection, University of Hull; SM. = Sedgwick Museum, Cambridge; YM. = Yorkshire Museum, York.

Suborder AMMONITINA Hyatt, 1889

Superfamily PERISPHINCTACEAE Steinmann, 1890

Family OLCOSTEPHANIDAE Haug, 1910

Subfamily SIMBIRSKITINAE Spath, 1924

Three genera, *Speetoniceras*, *Simbirskites* and *Craspedodiscus* were included in the subfamily by Wright (1957 : L349). *Speetoniceras*, *Craspedodiscus* and *Milanowskia*

(Chernova 1952) are here regarded as subgenera of *Simbirskites*, so that the subfamily now consists of *Simbirskites*, divided into four subgenera, and the provincial north American genera *Hertleinites* Imlay 1958 and *Hollisites* Imlay 1957.

The Simbirskitinae are a widespread and important group in the later Hauterivian beds of the Boreal Province, and are the last surviving members of the Middle Jurassic to Lower Cretaceous superfamily Perisphinctaceae, dying out at the end of the Hauterivian.

Genus *SIMBIRSKITES* Pavlow 1892

TYPE SPECIES: *Ammonites decheni* Roemer 1841, by original designation.

DIAGNOSIS: Ornament consists of short, sharp primary ribs branching into a varying number of secondary ribs; in most species there is a prominent tubercle at the point of branching in at least the earlier growth-stages. Other secondary ribs may branch from earlier ones higher on the whorl-flank, or may be intercalated. The ribs curve forwards on crossing the venter.

The external suture consists of five trifid lobes, a ventral, a lateral, and three auxillaries, separated by bifid saddles; none of the incisions within these major elements is deep. The suture is inverse (ascendent) i.e. if a radial line is drawn from venter to umbilical edge, the saddles are seen to ascend towards the aperture on approaching the umbilicus.

DISCUSSION: *Simbirskites* is a very variable genus, embracing evolute, coronate forms to involute, compressed forms. Within individual species there are often considerable changes in whorl proportions, rib pattern and rib density with growth. The genus was first proposed for "olcostephanids" of the *O. decheni* group, and subsequently (Pavlow 1901 : 67) divided into three groups, the Perisphinctoidea (group of *S. versicolor*), the Umbonati (group of *S. umbonatus* and *S. decheni*) and the Discofalcati (group of *S. discofalcatus*). Spath later divided *Simbirskites* into three genera, *Simbirskites* s.s. "restricted to the original coronate forms of the *decheni* group" (Spath 1924 : 87), *Speetonicerias*, proposed for the perisphinctoid early forms and therefore equivalent to Pavlow's Perisphinctoidea, and *Craspedodiscus*, proposed for the discoidal forms. The last genus included many of Pavlow's Discofalcati, though Spath included some of these in *Simbirskites*. In fact, Spath was inconsistent (Chernova 1952 : 46) in restricting *Simbirskites* to the coronate forms and then including in it *S. speetonensis* and *S. progredicus* which are moderately compressed species of Pavlow's Discofalcati group.

Wright (1957 : L350) followed Spath in regarding *Speetonicerias*, *Simbirskites* and *Craspedodiscus* as separate genera, placing two other genera, *Thysanotoceras* Whitehouse 1927 and *Stoicoceras* Whitehouse 1927, in synonymy with *Simbirskites*. *Thysanotoceras* was proposed for Weerth's (1884 : 12, pl. 2, fig. 5-6) *A. picteti*, and "includes the group with prominent bundling of costae in groups of four at the tubercle" (Whitehouse 1927 : 109). The genus is here regarded as a junior subjective synonym of *Simbirskites* s.s. *Stoicoceras* was not defined, but was proposed

for *A. teutoburgensis* Weerth (1884 : 20, pl. 5, fig. 1). This species is difficult to interpret, but appears to be a neocomitid.

Roman (1938 : 393) regarded *Speetonicer*as and *Craspedodiscus* as subgenera of *Simbirskites*, as did Bähr (unpublished dissertation)¹.

Chernova's (1952) major work on *Simbirskites* included detailed ontogenetic studies, from which she concluded that *Speetonicer*as and *Simbirskites* are separate genera. In the former genus Chernova included Pavlow's *Perisphinctoidea* and *Discofalcati*, and in the latter his *Umbonati* plus *S. coronatiformis* (M. Pavlow) and *S. pavlovae* Chernova (*nomen novum* for *S. elatus* M. Pavlow *non* Trautschold), which were originally included in the *Perisphinctoidea*. Chernova divided *Speetonicer*as into three subgenera, *Speetonicer*as *sensu stricto*, *Craspedodiscus* and a new subgenus, *Milanowskia*. *Simbirskites* remained undivided.

According to Chernova (1952 : 53) *Simbirskites* is more inflated than *Speetonicer*as *sensu* Chernova, though the earliest *Simbirskites* and contemporary *Speetonicer*as *s.s.* are very similar in the adult stage. In addition, she suggested that the sculpture in the two genera developed differently; in *Simbirskites* the tubercles normally appear first, followed by the primary ribs and lastly the secondaries, whereas in *Speetonicer*as the primary ribs appear first and are followed by the secondary ribs and then the tubercles. However, Chernova shows that in the two earliest (*versicolor* zone) species of *Simbirskites* (*S. coronatiformis* and *S. pavlovae*) the primary ribs appear before the tubercles (as in contemporary *Speetonicer*as). There thus seems no merit in placing any major phylogenetic significance on the order of appearance of each of these features. Furthermore, in practice it can be very difficult to decide which feature does appear first.

Chernova (1952 : 54) further assumed an independent origin for the two genera, deriving *Simbirskites sensu* Chernova from *Polyptychites* of the *gravesiformis* group (i.e. the forms separated by Pavlow (1913) as *Euryptychites*) and *Speetonicer*as *sensu* Chernova from another (undescribed) group of *Polyptychites* or from *Tollia*. On the available evidence it is more reasonable to derive *Simbirskites sensu* Chernova (the group here included in the restricted subgenus *Simbirskites*) from *S. (Speetonicer*as) *versicolor*, with *S. (S.) pavlovae* and *S. (S.) coronatiformis*, the two earliest Russian *Simbirskites s.s.*, as connecting links (see page 64).

It is impossible to draw sharp boundaries between *Craspedodiscus*, *Milanowskia*, *Simbirskites s.s.* and *Speetonicer*as, and all four are here regarded as subgenera of *Simbirskites*. In certain species the inner whorls have previously been placed in one genus and the outer whorls in another. Although the evolutionary relationship between some species appears clear, the complex *Simbirskites* lineages have by no means been unravelled completely and Chernova's (1951 : figs 1 and 2) detailed lineages are of doubtful value. At present, therefore, the division of *Simbirskites* into four subgenera is based as far as possible on phylogenetic studies, but as our knowledge of the interrelationships between various species increases the boundaries

¹Bähr, H. H., 1964. "Die Gattung *Simbirskites* (Ammonoidea) im Ober-Hauterive Nordwestdeutschlands". Unpublished dissertation, Technischen-Hochschule, Braunschweig. Referred to throughout this paper as "Bähr, unpublished dissertation".

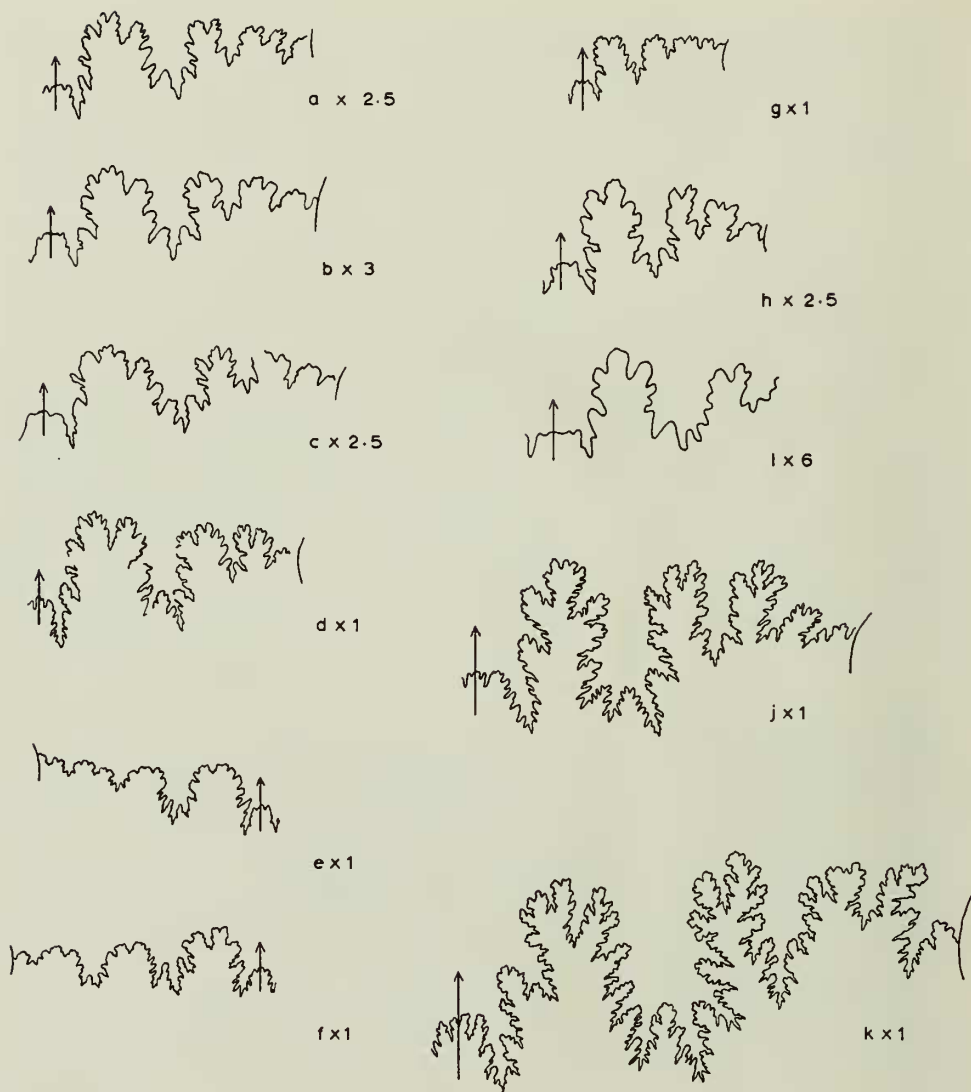


FIG. 2. Suture lines of *Simbirskites*. a-f sutures with relatively broad elements, g-k sutures with narrower, deeper elements. a. *S. (S.) cf. decheni* var. a, at 21 mm diameter (BM. C.75887). b. *S. (M.) concinnus*, at 20 mm diameter (HU. Rn.397). c. *S. (M.) staffi*, at 34 mm. diameter (NLfB Kp.37). d. *S. (Sp.) inversum*, at 85 mm. diameter (BM. C.4). e. *S. (S.) kowalewskii*. f. *S. (S.) umbonatiformis*. g. *S. (S.) decheni*. h. *S. (S.) yorkshirensis*, at 17 mm. diameter (BM. C.75885). i. *S. (S.) marginatus*, at 9.5 mm diameter (holotype, YM. tablet 414). j. *S. (M.) progredicus*. k. *S. (S.) umbonatus*.

figures a-d, h, i, original; figures e-g, j, k, redrawn from Pavlow (1901).

between the subgenera, and possibly the number of subgenera recognized, will doubtless require adjustment.

An outstanding problem, which can only be resolved after a detailed study of sutural ontogeny of the Russian, German and English forms, is the significance of the relative length and breadth of the elements of the suture. Both Pavlow (1901) and Chernova (1952) recognized that in some species of *Simbirskites* the saddles are broad and only slightly subdivided at all growth stages, while in other species they are narrow and longer and become more strongly subdivided with growth (Text-fig. 2). Pavlow (1901) regarded these sutural differences as the main feature distinguishing *S. (S.) umbonatiformis* from *S. (S.) umbonatus* and *S. (S.) kowalewskii* from *S. (S.) decheni*. This variation has not been observed in *Speetonicerias* (with broad saddles) and *Craspedodiscus* (with narrow saddles) but is recorded in *Milanowskia* and *Simbirskites* s.s. Observation of the limited amount of suitable Speeton material suggests that there may be a time significance, the earlier species having the broader saddles and later species the narrower saddles.

Simbirskites probably evolved in the Boreal Ocean from one of the late Valanginian polyptychitids; the time break between these and the earliest *Simbirskites* (*Speetonicerias*) is represented in the Russian successions by a stratigraphical break and in north-west Europe by beds with *Endemoceras*, an endemic boreal neocomitid genus derived from a tethyan ancestral stock.

Numerous species of *Simbirskites* have been described from the Russian Platform, north Germany, Heligoland and Speeton. Unfortunately, it is a particularly difficult genus to study; Pavlow (1901 : 66) has discussed the taxonomic difficulties caused by the considerable morphological changes which often occurred during growth. Failure to recognize these changes, or inadequate type material, has resulted in a proliferation of specific names and there are probably far more names available than there are species of *Simbirskites*.

Comparisons between the *Simbirskites* species of the various parts of the Boreal Province are further complicated by differences in size of the preserved specimens. At Speeton, most specimens are septate inner whorls rarely more than 25 mm in diameter, whereas many of the Russian species described by Lahusen (1874), M. Pavlow (1886) and A. P. Pavlow (1901) and the north German species of Neumayr and Uhlig (1881) were described from much larger specimens. The numerous species described by Weerth (1884) from the Teutoburger Wald and by Koenen (1904) from Heligoland were based upon small and medium-sized specimens directly comparable with the Speeton forms.

Outside the Anglo-German and Russian Platform regions, *Simbirskites* is rare. It has recently been recorded from Spitzbergen (see Parker 1967 : 502). From the Northern Richardson Mountains in the North-West Territories of Canada, Jeletzky (1964 : 58, pl. 15, fig. 2) has figured a poorly preserved, apparently simbirskitid, ammonite as *S. cf. kleini* (Neumayr and Uhlig). More definite records of *Simbirskites* are the species figured by Imlay (1960) from California and Oregon.

The description of an Australian species, *Simbirskites morvenae* (Whitehouse 1927 : 111), was based on material in an old collection in Queensland Museum

labelled "Victoria Downs, Morven". The record has not been substantiated by further collecting and Whitehouse (1946) subsequently questioned the provenance of the specimens as they closely resemble comparable German individuals in preservation. There is no other evidence for marine Hauterivian strata in the area.

Spath (1924 : 82, 87) included the Mexican and Himalayan "*Simbirskites*" described by Burckhardt (1912) and Uhlig (1910) respectively in the Upper Jurassic genus *Grayiceras*. Leanza's (1958) Argentinian *Simbirskites* have been misidentified generically. In lateral view *S. auracanus* Leanza is similar to *S. decheni* and *S. quadripartitus* Leanza resembles *S. kleini*, but all four of Leanza's species differ from *Simbirskites* in that the ribs extend straight across the venter instead of curving forwards. Leanza's species appear closer to *Rogersites*; the recorded stratigraphical horizon (late Valanginian) would agree with this.

Simbirskites occurs, very rarely, in the south of France; unfortunately the specimen from Barrême in the Astier collection (BM. 73463) referred to as "comparable to forms of C6" (Spath 1924 : 82) is too poorly preserved to be identified.

Subgenus *SPEETONICERAS* Spath 1924

TYPE SPECIES: *Sp. subbipliciforme* Spath 1924, by original designation.

DIAGNOSIS: A perisphinctoid subgenus of *Simbirskites* with a moderately evolute to evolute shell, rounded to coronate whorl section, and strongly biplicate ribbing. The suture has relatively broad, only slightly subdivided saddles and lobes at all growth stages.

DISCUSSION: Following Spath (1924 : 87), the subgenus *Speetoniceras* is here retained for the early perisphinctoid species of *Simbirskites*, i.e. Pavlow's (1901 : 67) "Perisphinctoidea, ou groupe de *Simbirskites versicolor*". Chernova (1952 : 50) also included within the subgenus the German group of *S. inverselobatus* (Neumayr and Uhlig).

Chernova (1952 : 50) states that all *Speetoniceras* species reach maturity at about 90 mm diameter and grow to as much as 500–600 mm diameter; within this growth-range the general form and sculpture of each species remains constant. Most of the large Russian specimens were originally included in *Sp. versicolor* (Trautschold), but after studying the ontogeny of the various forms M. Pavlow (1886) distinguished three species, *Sp. inversum*, *Sp. subinversum* and *Sp. versicolor*. There is a gradation between the three, *Sp. versicolor* having the most inflated inner whorls with strong tubercles and coarse ribbing, while at the other extreme *Sp. inversum* has the least inflated inner whorls with feeble tubercles and finer ribbing. With growth these differences diminish so that the outer whorls of the three species are virtually identical and can best be separated by sutural differences. The sutures of *Sp. inversum* were described as strongly inverse, those of *Sp. subinversum* less so, and those of *Sp. versicolor* only slightly inverse. The stratigraphical ranges of these three species in the Volga section reflect the morphological gradation; *Sp. versicolor*

appears first, followed by *Sp. subinversum* and then by *Sp. inversum* (Chernova 1951 : 52-53. Text-fig. 10 here).

Although large specimens of *Speetoniceras* are common in Russia, the Speeton material consists almost entirely of septate inner whorls of less than 30 mm diameter, so that it is difficult to compare specimens from the two areas.

Speetoniceras is not known from north Germany, but has been recorded from Spitzbergen (Parker 1967 : 502) and from Oregon (Imlay 1960 : 213).

***Simbirskites (Speetoniceras) subbipliciforme* (Spath)**

(Pl. 1, figs 2, 5)

1906 *Olcostephanus (Simbirskites)* ?sp. Danford: pl. 12, fig. 3.

1924 *Speetoniceras subbipliciforme* (= "sp." Danford, pl. 12, fig. 3) Spath: 76.

TYPE: The holotype, refigured here, pl. 1, fig. 2; GSM. 17930, Danford collection, from "C7-8" of the Speeton Clay.

MATERIAL: Six septate nuclei; author's collection BM. C.75620-21; HU. Rn. 26, Rn. 230, Rn. 1102; GSM. 17913. Speeton Clay, bed C7H (BM. C.75620-21 and Rn. 1102; horizon of others unrecorded).

DESCRIPTION: Known only from septate inner whorls, the largest being 28.7 mm in diameter. Shell evolute, whorl section rounded. Ribs strong, gently prorsiradiate; rib pattern regular, the short primary ribs normally bifurcating at a subdued swelling about a third of the distance over the whorl flank. Rarely, a primary rib remains unbranched. The secondary ribs curve forwards on crossing the rounded venter.

DIMENSIONS OF FIGURED SPECIMENS:

GSM. 17930 (holotype). 28.0; 10.2, 10.6, 11.2. 18 pr., approx. 34 sec. ribs.

BM. C.75620. 21.4: at 20.7; 7.5, 8.0, 8.0. 19 pr., approx. 36 sec. ribs.

DISCUSSION: *S. (Sp.) subbipliciforme* has not previously been described; the specific name was introduced by Spath (1924) as a *nomen novum* for Danford's (1906) figured "*Olcostephanus (Simbirskites)* ?sp.". The species differs from the inner whorls of other *Speetoniceras* in being more evolute, less inflated, and more coarsely ribbed; the secondary ribs curve forwards more strongly over the venter than in other species. It is approached only by the more coarsely ribbed varieties of *S. (Sp.) inversum*, which differ in being less evolute and a little more inflated.

DISTRIBUTION: Speeton Clay, *inversum* zone, Speeton.

***Simbirskites (Speetoniceras) inversum* (M. Pavlow)**

(Pl. 1, figs 1, 3, 4, 6, 7, 9; Pl. 2, fig. 1; Text-figs 2d, 3-5)

?1865 *Ammonites versicolor* Trautschold: pl. 2, fig. 3 (non fig. 4).

1886 *Ammonites (Olcostephanus) inversus* M. Pavlow: 36, pl. 1, figs 4, 5; pl. 2, fig. 1.

1892 *Olcostephanus (Simbirskites) inversus* (M. Pavlow) Pavlow: 508, pl. 18, fig. 14.

- ?1892 *Olcostephanus (Simbirskites)* aff. *inversus* (M. Pavlow); Pavlow: pl. 15, fig. 3.
 1892 *Olcostephanus (Simbirskites)* *subinversus* M. Pavlow; Pavlow: 507, pl. 18, fig. 12 (?fig. 13).
 1906 *Olcostephanus (Simbirskites)* *subinversus* (M. Pavlow); Danford: 110, pl. 12, fig. 4.
 ?1907 *Simbirskites inversus* (M. Pavlow) Karakasch: 129, pl. 13, fig. 4a, 4b (interior).
 1924 *Speetonicerias inversum* (M. Pavlow) Spath: 76.
 1924 *Speetonicerias subinversum* (M. Pavlow) Spath: 76.
 1960 *Speetonicerias inversum* (M. Pavlow); Drushchitz and Kudryavtseva: 273, pl. 17, fig. 2.

TYPE: M. Pavlow's figured syntypes are in the Geological Reconnaissance Institute, Moscow; the original of Pavlow's plate 1 figure 5, is here selected as lectotype.

MATERIAL: 29 septate inner whorls from bed C7H (common) and C7G (rare) of the Speeton Clay. Author's collection, BM. C.75622-46 (25 specimens) and HU. Rn. 147, Rn. 690, Rn. 708, and Rn. 937 (4 specimens). 2 specimens from Simbirsk, Russia, BM. C.4 (Damon collection) and Kabanov collection, number 1364. There is additional material from Speeton in all the collections examined.

DESCRIPTION (of specimens up to 30 mm diameter): Shell moderately evolute, flanks and venter rounded, whorl section sub-circular. Primary ribs extend almost half-way over the whorl-flank, where they bifurcate at a subdued tubercle; very rarely a primary rib either remains single or trifurcates. The secondary ribs curve gently forwards over the venter. There are 20-28 (usually 21-25) primary ribs and 40-55 secondary ribs per whorl at 16-32 mm diameter (Text-fig. 4).

The shell is smooth to 7-8 mm diameter, when primary and secondary ribs appear practically simultaneously; one individual (BM. C.75643) remains smooth for another half-whorl, to about 12 mm diameter.

The suture-line (Text-fig. 2d, 3) is inverse with broad, only slightly subdivided saddles.

DIMENSIONS OF FIGURED SPECIMENS:

- BM. C.75626. 20.5; 8.7, 8.0, 7.0. 23 pr., 46 sec. ribs.
 BM. C.75624. 24.8; 10.3, 10.0, 8.5. 27 pr., 49 sec. ribs.
 BM. C.75623. 27.2; 11.6, 12.8, 8.4. 25 pr., 50 sec. ribs.
 BM. C.75625. 29.6; 11.4, 11.2, 11.0. 23 pr., 46 sec. ribs.
 BM. C.75627. 31.2; 12.0, 13.0, 11.2. 27 pr., 50 sec. ribs.
 BM. C.75622. 35.4; 13.7, 14.1, 13.4. 21 pr., 41 sec. ribs.
 Kabanov colln. 1359. 78.5; 27.5, 27.2, 33.0. 32 pr., 64 sec. ribs.

DISCUSSION: This species is represented at Speeton by small, septate specimens up to 32 mm diameter; they are slightly less inflated than the smallest of Pavlow's syntypes (1886: pl. 1, fig. 5), a plaster cast of which has been made available by Professor Drushchitz. However, Chernova (1952: fig. 3) illustrated the whorl section of a Russian individual of 30 mm diameter, and this compares closely with whorl sections of Speeton specimens of similar diameter. M. Pavlow described the inner whorls of *S. (Sp.) inversum* as rounded, with feeble tubercles at the point of bifurcation of the ribs; at a later growth-stage the tubercles disappear and the

whorl flanks flatten. Large specimens, comparable in size to the typical Russian forms, are virtually unknown at Speeton, but the two large whorl fragments from Speeton figured by Pavlov (1892) as *S. (Sp.)* aff. *inversum* and *S. (Sp.)* *subinversum* may belong to *S. (Sp.)* *inversum*. A large Russian specimen is figured here (Pl. 1, fig. 4) for comparison.

The small Speeton specimens of *S. (Sp.)* *inversum* exhibit variation in general whorl proportions (Text-fig. 5), rib density (Text-fig. 4) and degree of inversion of the suture-line (Text-fig. 3). A. P. Pavlov (1892 : pl. 18, figs 12 and 14) figured two Speeton specimens as two different species, *S. (Sp.)* *inversum* and *S. (Sp.)* *subinversum*, separating them mainly according to the degree of inversion of the suture.



FIG. 3. *Simbirskites (Speetonicerias) inversum*: variation in degree of inversion of suture lines of 5 specimens from Bed C7H, Speeton. a. BM. C.75640 at 20.5 mm diameter; b. HU. Rn.937 at 18.2 mm diameter. c. BM. C.75645 at 25.0 mm diameter; d. BM. C.75625 at 28.6 mm diameter. e. BM. C.75627 at 30.2 mm diameter. All $\times 2$.

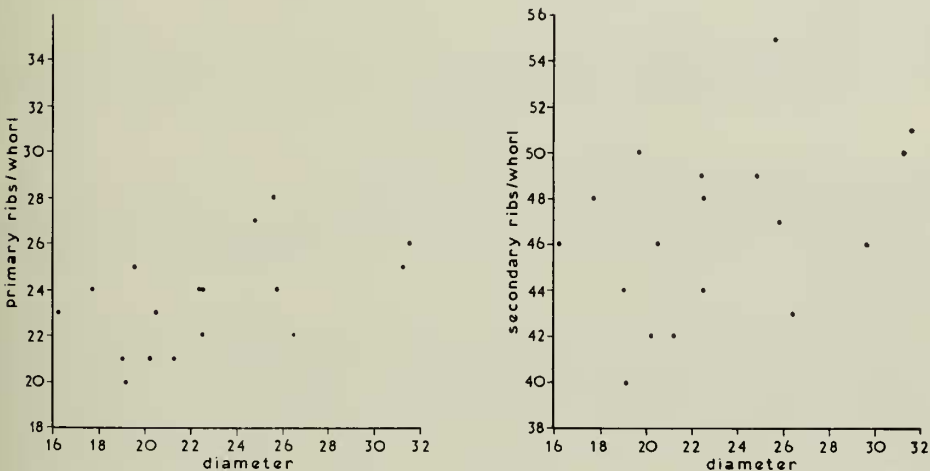


FIG. 4. Variation in density of primary and secondary ribs per whorl in 18 specimens of *Simbirskites (Speetonicerias) inversum* from Bed C7H, Speeton.

The difference between them is small and both fit into the range of variation of *S. (Sp.) inversum*. Danford's (1906) and Spath's (1924) records of *S. (Sp.) subinversum* from the Speeton Clay are apparently based on A. P. Pavlov's interpretation of the species.

S. (Sp.) agnessense Imlay differs from *S. (Sp.) inversum* in having more involute and more finely-ribbed inner whorls.

DISTRIBUTION: Speeton Clay, *inversum* zone, Speeton; *inversum* and *pavlovae* subzones of the *versicolor* zone, Russia.

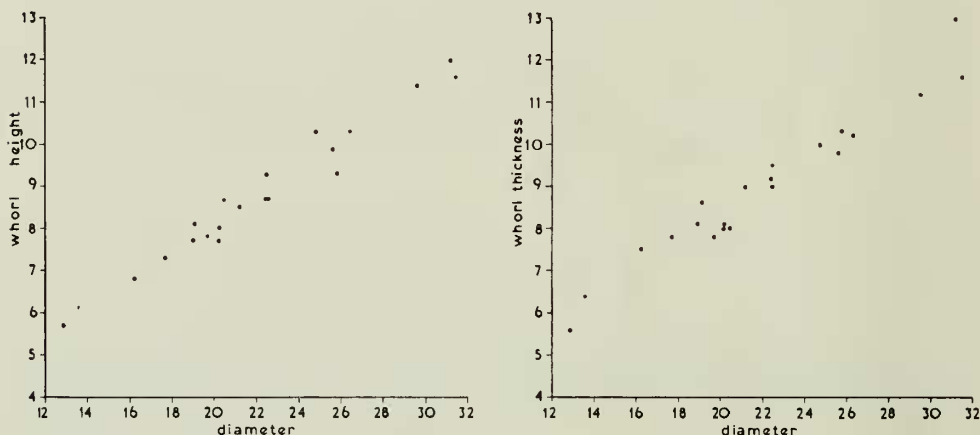


FIG. 5. Variation in whorl-proportions of 21 specimens of *Simbirskites (Speetonicerases) inversum* from Bed C7H, Speeton.

***Simbirskites (Speetonicerases) cf. versicolor* (Trautschold)**

(Pl. 1, fig. 8)

cf. 1865 *Ammonites versicolor* Trautschold: pl. 2, figs 3, 4.

cf. 1886 *Ammonites (Olcostephanus) versicolor* Trautschold; M. Pavlov: 30, pl. 1, figs 1-3.

MATERIAL: One septate specimen (author's collection, BM. C.75647) and one whorl fragment (HU. Rn. 84) from the C Beds of the Speeton Clay (exact horizon unknown).

DESCRIPTION: Shell moderately evolute, inflated, whorl section almost coronate. Coarsely ribbed, the short, sharp primary ribs branching into two, rarely three, secondary ribs at a prominent tubercle about a third of the way over the whorl flank. The secondary ribs curve gently forwards over the broadly rounded venter.

DIMENSIONS OF FIGURED SPECIMEN:

BM. C.75647. 30.4; 11.5, 14.6, 12.5. 20 pr., 44 sec. ribs.

DISCUSSION: The inner whorls of *S. (Sp.) versicolor* figured by M. Pavlow (1886) are similar to the Speeton specimens in degree of inflation, but the tubercle is higher on the flanks. However, Chernova's (1952 : fig. 3) diagrammatic cross-section at 30 mm diameter is very close to that of the Speeton example; the Speeton specimens are therefore provisionally referred to *S. (Sp.) versicolor*. They are considerably more inflated than the inner whorls of *S. (Sp.) inversum*.

The Speeton specimen(s) on which Spath's (1924 : 76) record of *S. (Sp.) versicolor* was based has not been traced.

DISTRIBUTION: Speeton Clay; exact horizon not known. *Versicolor* zone, Russia.

Simbirskites (Speetoniceras) sp.

(Pl. 1, fig. 10)

DISCUSSION: A small, partly crushed specimen (author's collection, BM. C.75648), 20.3 mm in diameter, appears close to *S. (Sp.) inversum* in general features but is more finely ribbed, having 30 primary and approximately 60 secondary ribs on the last whorl. The specimen came from the pale blue clay just above the hard stone band of C7F, the highest horizon from which *Speetoniceras* has so far been recorded at Speeton. A number of similar but completely crushed forms were found in the same bed but disintegrated on exposure.

Subgenus **MILANOWSKIA** Chernova, 1952

TYPE SPECIES: *Ammonites speetonensis* Young and Bird 1828, by original designation.

DIAGNOSIS: Shell moderately evolute to slightly involute, usually moderately compressed though the earliest whorls may be more inflated, resembling those of *Speetoniceras*. Short primary ribs normally branch at a subdued tubercle into 2–5 secondary ribs; other secondaries may appear higher on the whorl flank.

Both types of *Simbirskites* suture occur in *Milanowskia*.

DISCUSSION: Species of *Milanowskia* grew to large diameters, but the two commonest and best-known Speeton species, *S. (M.) concinnus* and *S. (M.) speetonensis*, are known only from septate inner whorls. *S. (M.) concinnus* is intermediate in form between the earlier *S. (Sp.) inversum* and the later *S. (M.) speetonensis*, but the relationship between other species is less clear. The origin of *S. (M.) staffi* and related forms from north Germany is particularly problematic, and this group was separated from *Milanowskia* by Bähr (unpublished dissertation) as a new subgenus.

Among the species of *Milanowskia* described here the earlier forms (*concinnus*, *speetonensis*, *staffi*, and *S. (M.) sp.*) have a suture with relatively broad, only slightly subdivided saddles, while the later *S. (M.) lippiacus* and *S. (M.) cf. lippiacus* have the narrower, longer, more strongly subdivided saddles typical of Chernova's (1952 : 50) *progredicus* group of *Milanowskia*.

Simbirskites (Milanowskia) concinnus (Phillips)

(Pl. 2, figs 2-6, 8; Pl. 12, fig. 11; Text-figs 2b, 6)

- 1829 *Ammonites concinnus* Phillips: 123, pl. 2, fig. 47.
 1835 *Ammonites concinnus* Phillips; Phillips: 94, pl. 2, fig. 47.
 1875 *Ammonites concinnus* Phillips; Phillips: 264, pl. 2, fig. 47.
 1889 *Olcostephanus speetonensis concinnus* (Phillips) Pavlow: pl. 3, fig. 7.
 1892 *Olcostephanus (Simbirskites) concinnus* (Phillips); Pavlow: 501, pl. 18, fig. 16.
 1892 *Olcostephanus (Simbirskites) progrediens* (Lahusen); Pavlow: 504, pl. 18, fig. 15.
 1906 *Olcostephanus (Simbirskites) concinnus* (Phillips); Danford: 110, pl. 12, fig. 2.
 1924 *Simbirskites? concinnus* (Phillips) Spath: 76.
 1924 *Simbirskites progredicus* (Pavlow 1892 *non auct.*) Spath: 77.
 1951 *Speetonicerus (Milanowskia) lahusei* Chernova: 63.
 1962 *Simbirskites concinnus* (Phillips); Howarth: 130, pl. 19, fig. 6.

TYPE: The holotype, originally in the Yorkshire Museum, York, has decomposed (Melmore 1947 : 235); the specimen figured by Pavlow (1892 : pl. 18, fig. 16) was designated neotype and refigured by Howarth (1962 : pl. 19, fig. 6). BM. C.4651.

MATERIAL: 65 septate inner whorls from the Speeton Clay; 62 from 0.3-0.9 metres above the base of bed C6 (author's collection, BM. C.75649-75709, C.75893); BM C.34953 (Lamplugh collection), HU. Rn. 397 and GSM. 30582 from C6. One specimen (author's collection, BM. C.75711) from the *capricornu* zone of Sarstedt, near Hannover. There is additional Speeton material in all the examined collections.

DESCRIPTION: Known only from septate inner whorls (up to 33.5 mm diameter). Shell moderately evolute with sub-circular whorl section and rounded flanks and venter. Sharp primary ribs branch a third of the way over the whorl flank at a feeble, radially elongate tubercle, into two or three secondary ribs. There are 18-25 (usually 19-22) primary ribs and 45-65 (usually 50-60) secondary ribs per whorl at diameters of 20-25 mm. The ribs are gently prorsiradiate, curving forwards over the venter. The shell is smooth to about 8 mm diameter when the primary and secondary ribs appear practically simultaneously.

The suture-line (Text-fig. 2b) is inverse, with broad, only slightly subdivided saddles.

DIMENSIONS OF FIGURED SPECIMENS:

- BM. C.75695. 17.5; 8.5, 8.0, 4.3.
 BM. C.75893. 20.4; 8.8, 9.7, 6.0. 20 pr., approx. 48 sec. ribs.
 BM. C.75706. 24.2; 10.5, 10.8, 7.4. 24 pr., 60 sec. ribs.
 BM. C.75708. 25.8; 11.0, 10.7, 7.8. 23 pr., 58 sec. ribs.
 BM. C.75711. 30.6; at 24.3; 10.3, 10.0, 7.1. 18 pr., approx. 46 sec. ribs.
 GSM. 30582. 33.5; 13.6, 12.8, 11.5. 22 pr., 55 sec. ribs.

DISCUSSION: The variation in the dimensions of this species is shown in Text-fig. 6; most of the specimens are less than 20 mm in diameter and the earliest part of the last preserved whorl is still smooth, so that few rib counts can be made. The

proportion of bifurcating to trifurcating ribs varies; at one extreme only about one third of the primary ribs trifurcate while at the other extreme every primary rib trifurcates. The neotype is a coarsely ribbed individual; at 27 mm diameter there

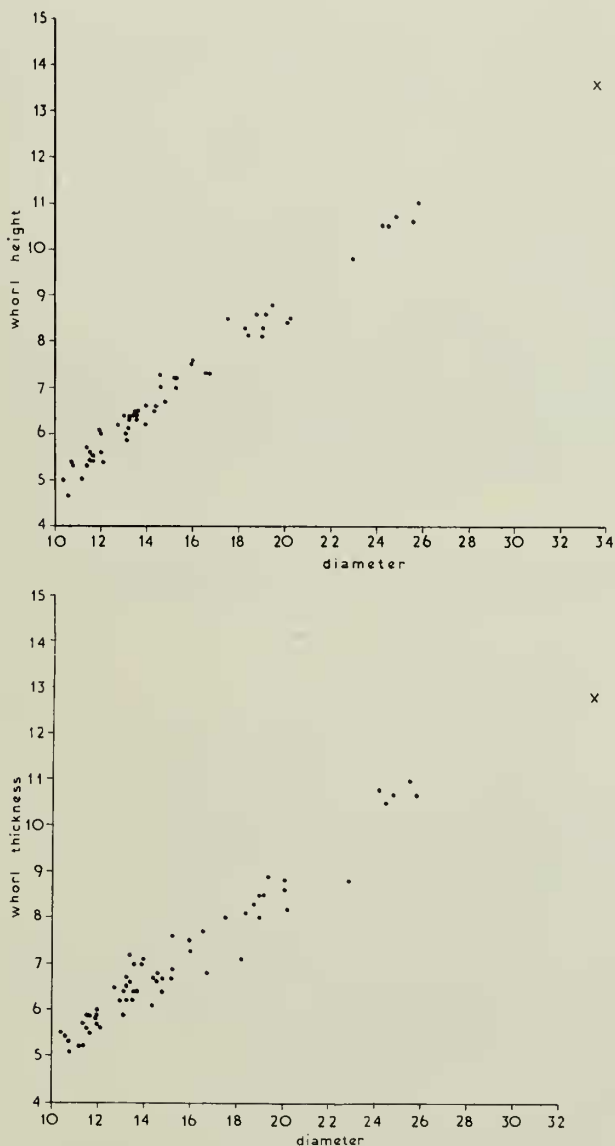


FIG. 6. Variation in whorl-proportions of 63 specimens of *Simbirskites* (*Milanowskia*) *concinus*, 62 specimens from Bed C6 (0.3–0.9 metres above base) and 1 specimen (GSM.30582, indicated by a X) from the C Beds, Speeton.

are 18 primary ribs and only about 46 secondary ribs. There is every range of variation between this and a finely ribbed, slightly less inflated specimen of *S. (M.) concinnus* figured by Pavlow (1892 : pl. 18, fig. 15) as "*Olcostephanus (Simbirskites) progrediens* (Lahusen)". Pavlow recorded this from C4 but Spath listed "*S. progrediens* (Pavlow, 1892 non auct.)" from C6. Pavlow's specimen (BM. C.34953) has 22 primary ribs and approximately 65 secondary ribs at 23 mm diameter, and compares closely with other finely-ribbed specimens of *S. (M.) concinnus* from low C6. Pavlow's specimen is the holotype of *S. (M.) lahusei* Chernova (1951 : 63), which was proposed as a *nomen novum* for *S. progrediens* (Pavlow 1892 non Lahusen). *S. (M.) lahusei* is here regarded as a junior subjective synonym of *S. (M.) concinnus*.

S. (M.) concinnus is close to *Speetonicerias*; the more coarsely ribbed specimens differ from the small Speeton examples of *S. (Sp.) inversum* only in the possession of trifurcating as well as bifurcating ribs. It has clearly evolved from *S. (Sp.) inversum*, and in turn gives rise to *S. (M.) speetonensis*.

S. (M.) concinnus resembles some of the varieties of *S. cf. decheni*, but is less inflated. It is more inflated and more evolute than *S. (M.) speetonensis*.

S. (M.) concinnus occurs in north Germany, but from the limited material available the German specimens appear to be more coarsely ribbed with fewer secondary ribs than the Speeton forms. A German specimen from the upper part of the *capricornu* zone, Sarstedt, is figured here (pl. 2, fig. 5).

DISTRIBUTION: Speeton Clay *speetonensis* zone, *concinnus* subzone; Lower Tealby Clay of Donnington-on-Bain, Lincolnshire (p. 35); upper part of *capricornu* zone, north Germany; *decheni* zone, *speetonensis* subzone, Russia.

***Simbirskites (Milanowskia) speetonensis* (Young and Bird)**

(Pl. 2, figs 7, 9–11, 15; Pl. 11, fig. 4)

- 1828 *Ammonites speetonensis* (sic) Young and Bird: 265, pl. 12, fig. 5.
- 1829 *Ammonites venustus* Phillips: 123, pl. 2, fig. 48.
- 1835 *Ammonites venustus* Phillips; Phillips: 94, pl. 2, fig. 48.
- 1874 *Ammonites fasciatofalcatus* Lahusen: pl. 7, fig. 1.
- 1875 *Ammonites venustus* Phillips; Phillips: 264, pl. 2, fig. 48.
- 1889 *Ammonites speetonensis* Young and Bird; Lamplugh 613 (*pars*).
- 1889 *Olcostephanus speetonensis venustus* (Phillips) Pavlow: 59, pl. 3, fig. 6.
- 1889 *Olcostephanus fasciatofalcatus* (Lahusen) Pavlow: 117, pl. 3, fig. 8.
- 1892 *Olcostephanus (Simbirskites) speetonensis* (Young & Bird) Pavlow: 500, pl. 18 (11), fig. 7.
- 1901 *Simbirskites speetonensis* (Young and Bird) Pavlow: 76, pl. 4, fig. 1, pl. 7, fig. 4.
- 1906 *Olcostephanus (Simbirskites) payeri* (Toula); Danford: pl. 12, fig. 1.
- 1924 *Simbirskites venustus* (Phillips); Spath: 77.
- 1924 *Simbirskites speetonensis* (Young and Bird); Spath: 77.
- 1952 *Speetonicerias (Milanowskia) speetonensis* (Young and Bird) Chernova: 50.
- ?1960 *Speetonicerias speetonensis* (Young and Bird); Drushchitz and Kudryavtseva: 274, pl. 19, fig. 1.
- 1962 *Simbirskites speetonensis* (Young and Bird); Howarth: 131, pl. 19, fig. 2.
- 1962 *Simbirskites venustus* (Phillips); Howarth: 131, pl. 19, fig. 3.

TYPE: BM. C.34951 (Lamplugh collection), figured by Pavlow (1892 : pl. 18, fig. 7), was designated neotype and refigured by Howarth (1962 : 131, pl. 19, fig. 2). Bed C6, Speeton.

MATERIAL: 21 septate inner whorls from Speeton; 17 (author's collection, BM. C.75835-51) from the upper part of Bed C6; GSM. 17919 (Danford collection) from C6; YM. tablet 419 (holotype of *Ammonites venustus* Phillips); Neale collection 1701 from C6; Wrights' collection 18670. One specimen from Ulyanovsk (Simbirsk) (Göttingen, Orig. Nr. 609-1). There is additional material in all the collections examined.

DESCRIPTION: (of specimens up to 25 mm diameter): Shell slightly to moderately involute, slightly inflated to moderately compressed. Whorl flanks gently rounded in the slightly inflated forms, almost flat in the more compressed varieties. Ribs gently prorsiradiate; at first the short primary ribs branch at a subdued tubercle about a third of the way over the whorl flank into two or three secondary ribs, then above about 20 mm diameter a third or fourth secondary rib is normally intercalated. The ribs curve forwards over the rounded venter. There are 20-30 primary ribs per whorl at 20-25 mm diameter; in the specimens with fine primary ribbing only three secondary ribs are usually associated with each primary.

The suture has relatively broad elements.

DIMENSIONS OF FIGURED SPECIMENS:

BM. C.75847. 18.7; 8.5, 7.5, 5.3. 26 pr., approx. 61 sec. ribs.

GSM. 17919. 20.8; 9.0, 8.0, 6.2. 26 pr., approx. 66 sec. ribs.

Wright's colln. 18670. 21.3; 10.0, 8.1, 5.0. 30 pr., approx. 70 sec. ribs.

BM. C.75850. 21.7; 9.9, 8.0, 6.2. 22 pr., approx. 64 sec. ribs.

HU. Neale colln. 1701. 22.5; 10.5, 8.5, 5.7. 25 pr., approx. 64 sec. ribs.

DISCUSSION: Small, septate specimens of *S. (M.) speetonensis* are moderately common in the upper half of Bed C6 at Speeton; the largest known Speeton example (the neotype) is only 34 mm in diameter. They vary in whorl proportions and ribbing, and the "typical" compressed, moderately involute forms with flattened flanks (e.g. the neotype and BM. C.75850) are rare. The commonest forms are less involute and slightly inflated, with rounded flanks. In museum collections these are often labelled as *S. venustus* (Phillips), though Howarth (1962) has shown that Phillips' holotype is almost identical at similar diameter to the neotype of *S. (M.) speetonensis*, of which it is a junior subjective synonym.

Some of the more evolute, slightly inflated varieties of *S. (M.) speetonensis* have moderately coarse ribbing and approach the more finely ribbed varieties of *S. (M.) concinnus*. They are still not as inflated or as coarsely ribbed as the latter species but are clearly derived from it. These forms occur in the lower part of the range of *S. (M.) speetonensis* and the more "typical" forms near the top.

The specimen figured by Danford (1906 : pl. 12, fig. 1) as *S. payeri* (Toula) is refigured here (pl. 2, fig. 15) as a finely ribbed variety of *S. (M.) speetonensis*.

A more advanced growth stage of this species was described from Russia (Lahusen 1874) as *Ammonites fasciatofalcatus*. Pavlow (1892, 1901) subsequently included Lahusen's species in synonymy with *S. (M.) speetonensis* and refigured (Pavlow 1901: pl. 4, fig. 1) Lahusen's holotype, illustrating the opposite flank to that shown in Lahusen's original figure. Pavlow's illustration shows the inner whorls to be very close to the neotype of *S. (M.) speetonensis*, and the similarity is emphasized by another Russian specimen which Pavlow presented to the Göttingen collections (609-1). Both flanks of the Göttingen specimen are figured here. The outer whorl (Plate 11, fig. 4b) is identical to Lahusen's *S. fasciatofalcatus* while the earlier whorls (Plate 11, fig. 4a) are the same as those of *S. (M.) speetonensis*.

The Russian examples of *S. (M.) speetonensis* thus show that above about 40 mm diameter the number of secondary ribs usually decreases to three per primary, and these branch from a small, mid-lateral tubercle. The whorls are slightly involute with flattened flanks. This morphology persists to at least 100 mm diameter (Pavlow 1901: pl. 7, fig. 4). No examples of this morphological stage have yet been found at Speeton.

Septate nuclei of a form close to *S. (M.) speetonensis* occur in the lower part of the German *seeleyi* zone (p. 76).

DISTRIBUTION: *Speetonensis* subzone of the *speetonensis* zone, Speeton; *speetonensis* subzone, *decheni* zone, Russia; *seeleyi* zone, Germany (*S. (M.) ?speetonensis*).

Simbirskites (Milanowskia) sp. (= S. progredicus Danford non Lahusen)

(Pl. 2, figs 12, 13)

Non 1874 *Ammonites progredicus* Lahusen: pl. 6, fig. 3.

?1902 *Simbirskites elatus* Trautschold; Koenen: pl. 6, figs 10-12.

1906 *Olcostephanus (Simbirskites) progrediens (sic)* Lahusen; Danford: pl. 12, fig. 5.

MATERIAL: Three, two septate specimens in the Danford collection, GSM. 21556 and 17923 (the latter figured by Danford) and part of the body chamber and inner whorls of a third specimen in the author's collection, BM. C.75714. All from the Speeton Clay C Beds, exact horizon unknown.

DESCRIPTION: Shell slightly involute, moderately compressed, whorl section oval, broadest in the lower third of the whorl and narrowing towards the rounded venter. Ribs gently prorsiradiate, curving forwards over the venter; short, sharp primary ribs branch at a small, well-developed tubercle about a third of the way over the whorl flank into three, or rarely two, secondary ribs.

DIMENSIONS OF FIGURED SPECIMEN:

GSM. 17923. 26.9; 11.6, 10.3, 8.4. 20 pr., 59 sec. ribs.

DISCUSSION: GSM. 17923 was figured by Danford as *S. progredicus* (Lahusen)e although the two species are close in rib pattern the flanks of *S. progredicus* converg;

conspicuously towards the narrowly rounded venter at all growth stages (Pavlow 1901 : pl. 2, figs 4, 5) while those of *S. (M.)* sp. are flatter. The Speeton ammonite which Pavlow (1892 : pl. 18, fig. 15) figured as *S. progredicus* is more inflated and belongs to *S. (M.) concinnus* (p. 50). A specimen in the Göttingen collection, figured by Koenen (1902) as *S. elatus* (Trautschold), is close to *S. (M.)* sp. in general proportions but has more bifurcating primary ribs. A septate nucleus from Speeton in the Neale collection (S1726) is slightly more involute than *S. (M.)* sp. and the tubercles at the points of branching of the ribs are less well developed.

S. (M.) sp. is more compressed than *S. (M.) concinnus* and more coarsely ribbed than *S. (M.) speetonensis*. It differs from both in having more clearly developed tubercles at the points of branching of the ribs.

Danford recorded his figured specimen from C6, and his other specimen (GSM. 21556) from "C upper".

Simbirskites (Milanowskia) staffi Wedekind

(Pl. 2, figs 14, 16; Pl. 3, figs 1, 4; Text-fig. 2c)

1910 *Simbirskites staffi* Wedekind: 96, pl. 4, fig. 3.

TYPE: The holotype, in the Geologisches-Paläontologisches Institut, Göttingen, is from the *capricornu* Zone at Ihme, near Hannover.

MATERIAL: Two: author's collection BM. C.75712 from C6, 0.6 metres above the base, and BM. C.75713 (loose on cliff face, Speeton).

DESCRIPTION: The septate inner whorls of one individual and a whorl fragment of another are the only known Speeton representatives of this species. Whorls evolute, moderately compressed, with almost flat flanks and a narrow, well-rounded venter. Umbilicus shallow, broad, occupying almost a third of the diameter. Ribs slightly prorsiradiate; the primaries are short, extending about a third of the way over the whorl flank where they bifurcate at a small, radially elongated tubercle. A third secondary rib frequently appears higher on the flank, branching from the anterior side of the posterior rib of the original pair so that a virgatome pattern develops. The secondary ribs curve strongly forwards over the venter.

DIMENSIONS OF FIGURED SPECIMENS:

BM. C.38369. 42.0; 15.0, 11.7, 16.6. 22 pr., 60 sec. ribs.

NLFB Kp.37. 34.4; 12.9, 11.2, 12.9. 22 pr., 58 sec. ribs.

BM. C.75712. 27.2; 10.6, 8.7, 9.9.

BM. C.75713. 27.8; at 26.0; 9.6, 8.3, 9.9. 20 pr., 58 sec. ribs.

DISCUSSION: Two German specimens of *S. (M.) staffi* are figured here for comparison with the Speeton specimens. The latter are slightly more evolute than the holotype but fit well into the range of variation of a series of specimens in the

Göttingen collections. The holotype has 18 primary ribs at a diameter of 28 mm.

S. (M.) staffi differs from species of the *S. (M.) speetonensis* group in its virgotome rib pattern. It is close to two Heligoland species described by Koenen (1904) as *S. paucilobus* and *S. triplicatus*, but is more evolute. *S. virgifer* (Neumayr and Uhlig) approaches *S. (M.) staffi* in rib pattern, but the holotype is a large individual not directly comparable with the much smaller examples of *S. (M.) staffi*. Koenen (1904 : pl. 21, fig. 2) figured a small specimen which he assigned to *S. virgifer* but which may not be conspecific with Neumayr and Uhlig's species; it appears close to *S. (M.) staffi* but is more involute.

Although not previously recorded from Speeton, *S. (M.) staffi* is one of the commonest German *Simbirskites*; it is found associated with rare *S. (M.) concinnus* immediately above the beds with abundant *Aegocrioceras* spp. The only accurately localized Speeton specimen (BM. C.75712) was found in the identical stratigraphical position associated with numerous *S. (M.) concinnus*.

DISTRIBUTION: Speeton Clay, *concinnus* subzone, Speeton. Upper part of the *capricornu* zone and lower part of the *hildesiense* zone, north Germany.

Simbirskites (Milanowskia) lippiacus (Weerth)

(Pl. 3, figs 2, 5)

1884 *Ammonites (Olcostephanus) lippiacus* Weerth: 13, pl. 3, fig. 3, pl. 5, fig. 3.

1902 *Simbirskites lippiacus* Weerth; Koenen: 160, 416, pl. 37, fig. 3.

TYPES: The syntypes, originally at Detmold, are believed lost.

MATERIAL: Two specimens from Tönsberg, near Oerlinghausen; Weerth Collection, Göttingen, Orig. Nr. 457-125, 609-2.

DESCRIPTION: Shell slightly evolute, moderately compressed with flattened flanks and narrowly rounded venter. Primary ribs strong, gently prorsiradiate, terminating a third of the way over the flank at a tubercle, from which arise two or three secondary ribs. Some secondaries branch at varying positions higher on the flank and other, long secondaries may be intercalated about half-way over the flank. 5-7 secondaries are associated with each primary. The secondaries curve strongly forward over the venter.

DIMENSIONS OF FIGURED SPECIMENS:

Göttingen. Orig. Nr. 457-125. 92.8: at 86.0; 35.6, —, 24.9.

Göttingen. Orig. Nr. 609-2. 44.2: at 40.5; 17.0, 12.2, 10.9.

DISCUSSION: Weerth's type specimens are believed lost and the species has not been refigured, so that the two Göttingen topotypes are important for the interpretation of the species. The larger of the two (457-125) was discussed, and its suture figured, by Koenen (1902 : 160, pl. 37, fig. 3). It appears slightly more

evolute than the larger of the two syntypes (Weerth 1884 : pl. 3, fig. 3) but, as Koenen noted, the figure is inaccurate in this respect, for Weerth's description and dimensions indicate a slightly more evolute shell than is shown in his figure.

A neotype for this species will not be selected until the loss of the syntypes is definitely established.

The species is not definitely known from Speeton, but four whorl fragments are described below as *S. cf. lippiacus*.

***Simbirskites (Milanowskia) cf. lippiacus* (Weerth)**

(Pl. 3, fig. 3)

MATERIAL: 4 whorl fragments: BM. C.75715-16 (author's collection) from the stone band in Bed C2E, Speeton; BM. C.72643 (Lamplugh collection); GSM. 17542 (Danford collection) "Upper C".

DISCUSSION: The material is too fragmentary to be definitely referred to *S. (M.) lippiacus*; three of the specimens are similar in general proportions though possibly slightly less compressed, and the primary ribs only extend about a quarter of the way over the flank. The fourth (BM. C.72643) is more involute and more inflated than the Göttingen specimens.

Subgenus ***CRASPEDODISCUS*** Spath 1924

TYPE SPECIES: *Ammonites discofalcatus* Lahusen 1874, SD Wright 1957, L350.

DIAGNOSIS: A subgenus of *Simbirskites* with compressed, involute, finely ribbed whorls in at least one growth-stage. Early *Craspedodiscus* (*gottschei* group) become more compressed and more evolute with growth, while later *Craspedodiscus* (*discofalcatus* group) become more compressed and more involute with growth, becoming oxycone in the adult stage.

The suture has long, narrow saddles and lobes which become strongly subdivided during growth.

DISCUSSION: The boundary between this subgenus and *Milanowskia* is an arbitrary one and is here drawn where the whorls in at least one growth-stage are compressed and involute. *Craspedodiscus* includes at least two separate radiations, probably from *Milanowskia*, an earlier *kayseri-gottschei* group, with rather evolute, almost preisphinctoid outer whorls, and a later *discofalcatus-juddi* group with an oxycone adult stage. *S. (C.) variabilis* probably represents a third offshoot from *Milanowskia*. Until the ontogeny of some of these species is known in greater detail and their relationship to the various species of *Milanowskia* more clearly understood, it is inadvisable to split the group into more subgenera.

Simbirskites (Craspedodiscus) gottschei (Koenen)

(Pl. 4, figs 2, 4, 5; Pl. 5, fig. 1)

- 1892 *Olcostephanus (Simbirskites) discofalcatus* Lahusen; Pavlow: 505, pl. 18 (11), fig. 2.
 1904 *Craspedites gottschei* Koenen: 32, pl. 1, figs. 3, 4.
 1910 *Simbirskites extremus* Wedekind: 97, pl. 4, fig. 4.
 1924 *Craspedodiscus gottschei* (Koenen) Spath: 77.

TYPE: The original of Koenen 1904, pl. 1, fig. 3, in the Göttingen collection, is designated lectotype.

MATERIAL: Eight specimens; BM. C.75717-19 (author's collection) from bed C4L, Speeton, BM. C.34958, BM. C.4704, BM. C.27673, and GSM. 21555 (Danford collection, "C4") and Wrights' collection 24375 (probably C4).

DESCRIPTION: Inner whorls involute, compressed, with a narrowly arched venter. Primary ribs gently prorsiradiate, extending slightly more than half-way over the whorl flank. There are 21-26 primary ribs per whorl at 35-45 mm diameter; three or four secondaries are associated with each primary, but there is no definite point of branching and the ribs are frequently weakened on mid-flank. At first, all the secondary ribs either branch from the primary or are intercalated a little more than half-way over the flank, but above 25-30 mm diameter very occasional primary ribs branch, or a long secondary is intercalated, low on the whorl-flank. These longer secondary ribs may branch again later.

The outer whorls (above 150 mm diameter) are evolute and less compressed; whorls of intermediate size (70-150 mm) have not been found. On the outer whorls there are four to six broad, shallow, oblique constrictions. Primary ribs branch about half-way over the whorl into a bundle of three or four secondary ribs, though the point of branching is usually obscure. Some secondaries are intercalated; the secondaries curve gently forwards across the rounded venter. Both primary and secondary ribs are strongly prorsiradiate.

The suture-line has moderately narrow, elongate elements.

DIMENSIONS OF FIGURED SPECIMENS:

BM. C.75717. 40.3: at 32.1; 15.9, —, 6.0.

BM. C.4704. 40.9: at 39.2; 18.9, 14.0, 8.8. 23 pr., approx. 74 sec. ribs.

Wright's colln. 24375. 184: at 165.5; 55, 35.5, 68.

at 43.7 there are 26 pr. and approx. 93 sec. ribs.

DISCUSSION: The holotype of *S. (C.) extremus* Wedekind (Göttingen collection) is almost identical in rib pattern and general proportions to the lectotype of *S. (C.) gottschei*, differing only in being more coarsely ribbed; it is here regarded as a junior subjective synonym of *S. (C.) gottschei*. There is some variation in the rib density of the inner whorls of the Speeton specimens; hence BM. C.75718 and Wrights' specimen closely resemble the lectotype of *S. (C.) gottschei* while BM. C.75717 is close to the holotype of *S. (C.) extremus*. Both BM. C.75717 and C.75718 came from bed C4L.

BM. C.34958 was figured by Pavlow (1892) as *S. (C.) discofalcatus* and was later (Pavlow 1901 : 79) reidentified as *S. (C.) phillipsi*; this and a smaller specimen (BM. C.4704; pl. 4, fig. 2) are here regarded as inflated varieties of *S. (C.) gottschei*.

The outer whorls of *S. (C.) gottschei* have not been figured before; the excellent specimen in the Wrights' collection has just over three quarters of an evolute outer whorl preserved, of which slightly more than half the whorl is body chamber. The last sutures are not conspicuously crowded, and in the absence of any noticeable uncoiling of the body chamber the specimen cannot definitely be regarded as adult. A second, crushed specimen (BM. C.75718) has three quarters of a whorl of incomplete body chamber preserved. The outer whorls are close to those of *S. (C.) kayseri* (Neumayr and Uhlig). The inner whorls of the latter differ from those of *S. (C.) gottschei* only in having fewer secondary ribs per primary, and stronger, more clearly defined primary ribs (Bähr, unpublished dissertation).

DISTRIBUTION: *gottschei* zone, Speeton; *seeleyi* and possibly *tenuis* zones, Germany; *decheni* zone, *speetonensis* and *discofalcatus* subzones, Russia.

***Simbirskites (Craspedodiscus) cf. kayseri* (Neumayr and Uhlig)**

cf. 1881 *Perisphinctes kayseri* Neumayr and Uhlig: 146, pl. 19, fig. 1.

MATERIAL: Two septate inner whorls in the Neale collection, S. 1730 and S. 1682, and a third specimen in the British Museum, C. 4705.

DISCUSSION: The three specimens resemble the inner whorls of the more compressed varieties of *S. (C.) gottschei*, differing in having only two or three secondary ribs associated with each primary; they are identical to a specimen of similar size which Bähr (unpublished dissertation) figured as the inner whorls of the large *S. (C.) kayseri* (Neumayr and Uhlig).

In north Germany this species appears low in the *seeleyi* zone (Bähr, unpublished dissertation) and apparently gave rise to *S. (C.) gottschei*.

***Simbirskites (Craspedodiscus) variabilis* sp. nov.**

(Pl. 4, figs 1, 3, 6; Pl. 5, figs 3, 4)

1906 *Olcostephanus (Simbirskites) decheni* Roemer; Danford: pl. 12, fig. 7.

1924 *Simbirskites* aff. *toensbergensis* (Weerth) (= "*decheni*" Danford *non* Roemer); Spath: 77.

1924 *Simbirskites trifurcatus* (Bean MS.); Spath: 77.

?1967 ?*Simbirskites toensbergensis* (Weerth); Kemper: 126, pl. 11, figs 3, 4.

DIAGNOSIS: Shell compressed; inner whorls involute, with short primary ribs ending at a small tubercle. Four to six secondary ribs are associated with each primary. Outer whorl slightly evolute, with more regular rib pattern; number of secondary ribs reduced to three per primary.

TYPE SERIES: Holotype: HU. Rn. 700, from Bed LB6 of the Speeton Clay, Speeton; Paratypes: 11 specimens, 9 in the author's collection, BM. C.75853-61; Neale collection 1901; BM. C.4649. LB6, C2B (base) and C2C, Speeton.

DESCRIPTION: Shell compressed, inner whorls involute up to 40-50 mm diameter, becoming slightly evolute on the outer whorl (body chamber). Earliest whorls (Pl. 5, fig. 3), up to 18 mm diameter, slightly inflated with short, widely spaced primary ribs which end at a small, sharp tubercle. Four or five secondary ribs are associated with each primary; some of these join the tubercle and the others are intercalated at about the same level. Above about 18 mm diameter a sixth rib may appear and the mode of branching becomes rather irregular (Pl. 4, figs 3c, 6; Pl. 5, fig. 4); two or three secondary ribs branch from the tubercle, another rib may be intercalated at about the same level, and one of the secondaries may branch again a little higher on the flank.

The number of primary ribs increases with growth, from 9 at 14 mm diameter to 16 at 35 mm diameter and about 25 at 80 mm diameter. Above about 50 mm diameter the number of secondary ribs per primary decreases to three (rarely, two or four) (Pl. 4, figs 1, 3a). Of these, two branch from the tubercle and a third branches from one of the original pair slightly higher on the whorl. Less commonly, one secondary rib is intercalated instead of joining the tubercle.

In individuals from C2 some secondary ribs branch again close to the venter; this may happen in both inner and outer whorls.

DIMENSIONS OF FIGURED SPECIMENS:

BM. C.4649. 79.9; 29.2, 19.1, 27.0. 24 pr., 80 sec. ribs (estimated).

BM. C.75853. 28.7; 14.6, 8.8, 6.0. 14 pr., approx. 60 sec. ribs.

BM. C.75857. 14.0; 6.8, 6.2, 3.6.

DISCUSSION: This species has previously been recorded as *S. trifurcatus* Bean MS., and a specimen in Bean's collection (BM. C.4649) bearing his label "*Am. trifurcatus*" is the original of Spath's record of this manuscript name. It consists of one whorl of body chamber with trifurcating ribs. Spath recorded the specimen from C4, probably because the matrix invites comparison with some of the siltstone bands on this part of the Speeton section; it is much more likely that Bean obtained it from LB6, where the holotype and one of the paratypes were collected. The preservation of the specimen and its associated matrix supports this view. There are two varieties of this species; in specimens from bed C2 some secondary ribs branch again near the venter, a feature which has not been noted in the specimens from LB6 or in Bean's specimen.

The species is known from early whorls and from body chamber fragments with associated external moulds of the inner whorls; by placing body chamber against mould it has proved possible to make latex casts showing the form of the penultimate whorl (Pl. 4, fig. 3c, Pl. 5, fig. 4). There is no definite evidence that any of the specimens are adult; the modification of the ribbing and change in tightness of

coiling of the shell is a recurring feature in *Simbirskites* and frequently occurs well before the adult stage is reached.

The earliest whorls of this species are similar to those of *S. (S.) yorkshirensis* but are less inflated with less prominent tubercles. Whorls of intermediate size (20–50 mm diameter) differ from the inner whorls of *S. (C.) discofalcatus* in being more compressed with a less regular rib-pattern. *S. (C.) gottschei* is less compressed, the secondary ribs appear higher on the whorl flank, and there are no tubercles. The outer whorl of *S. (C.) variabilis* is close to Russian examples of *S. (M.) speetonensis* of similar diameter, but the inner whorls are more compressed, and more involute, and have a less regular rib pattern with slightly more secondary ribs per primary, than Speeton and Russian examples of *S. (M.) speetonensis* of comparable size.

Danford's (1906) figured *S. decheni* has decomposed, but a plaster cast (GSM. 17920) shows that it can be referred to *S. (C.) variabilis*.

The derived specimens from Alstätte which Kemper (1967) figured as ?*S. toensbergensis* may belong to *S. (C.) variabilis*, though the outer whorl has more numerous secondary ribs per primary than in the Speeton species.

DISTRIBUTION: Speeton Clay, *variabilis* zone, Speeton.

Simbirskites (Craspedodiscus) discofalcatus (Lahusen)

(Pl. 7, fig. 1; Pl. 8, fig. 1; Pl. 9, figs 1, 2; Pl. 11, figs 2, 3, 5)

- 1874 *Ammonites discofalcatus* Lahusen: 67, pl. 7, figs 2–4.
- 1890 *Olcostephanus discofalcatus* (Lahusen) Pavlow: 2, pl. 6, fig. 1.
- 1901 *Simbirskites discofalcatus* (Lahusen) Pavlow: 78, pl. 6, fig. 1; pl. 7, fig. 2 (*non* 3).
- cf. 1906 *Olcostephanus (Simbirskites) discofalcatus* (Lahusen); Danford: pl. 12, fig. 8.
- 1924 *Craspedodiscus discofalcatus* (Lahusen) Spath: 77–79.
- 1924 *Simbirskites aff. fasciatofalcatus* (Lahusen); Spath 1924 : 79.
- 1960 *Craspedodiscus discofalcatus* (Lahusen); Drushchitz and Kudryavtseva: 274, pl. 19, fig. 2, ?fig. 3.

TYPE: Following Bähr (unpublished dissertation) the original of Lahusen's pl. 7, fig. 2–3, is proposed as lectotype: Mining Museum, Leningrad Mining Institute, catalogue number. $\frac{19}{48}$.

MATERIAL: 2 specimens and 2 whorl fragments from the Speeton Clay: GSM. 21493 (Danford collection, "B. Base") and York Museum (no number); GSM. 17543 and 21494 (Danford collection; whorl fragments). 7 specimens from the Tealby Limestone: GSM. 30883 (Judd collection) and BM. C.19993 (P. F. Kendall collection) from North Willingham, BM. C.73376–78 (J. E. Lee collection) and BM. C.25183 from Normanby, and SM. B11123 from Claxby (erroneously recorded from the Claxby Ironstone).

In addition, 2 Speeton specimens (GSM. 17922 (Danford collection) and BM. C.72641 (Lamplugh collection)) are figured here as *S. (C.) cf. discofalcatus*.

DESCRIPTION (of specimens more than 100 mm in diameter): Shell compressed, involute, with narrowly rounded venter. Whorl broadest near the umbilical edge; umbilicus moderately shallow, umbilical wall fairly steep. Rib pattern irregular; 4 or 5 secondary ribs are associated with each primary, but their point of origin is usually obscure. Some arise from a primary rib about a third of the way over the whorl, others are intercalated either in the middle or on the outer part of the whorl. There are 19–23 primary ribs and 100–120 secondary ribs per whorl at about 120 mm diameter.

The strength of the ribs gradually diminishes with growth (Plate 7), until at diameters above 150–200 mm the shell becomes almost smooth, ornamented only by feeble rib-folds or striae (Plate 8).

The suture has long, narrow, strongly divided saddles and lobes.

DIMENSIONS OF FIGURED SPECIMENS:

BM. C.5. 101: at 86·7; 43·3, 22·2, 17 (approx.). Approx. 22 pr. ribs at 101 mm diam.

BM. C.73376. 122·4: at 115·3; 57·8, 30·3, 18·2. 20 pr., approx. 112 sec. at 122 mm diam.

BM. C.73377. 212·5; 109·5, 47 (approx.), 26·0. 24 pr. ribs.

BM. C.19993. 234·0; 119·5, 52·5, 29·0.

DISCUSSION: Only two specimens (GSM. 21493 and SM. B11123) show the inner whorls, and they are poorly preserved. At small diameters (less than 45 mm) the inflation of the whorl is similar to that of some species of *Milanowskia*, but with growth *S. (C.) discofalcatus* becomes proportionately more compressed; Pavlow (1901 : 79) has discussed in detail the changes in whorl proportions and ornamentation with growth. A small, slightly distorted specimen of 25 mm diameter figured by Danford (1906 : pl. 12, fig. 8) is refigured here (Pl. 11, fig. 2), together with a similar individual in the Lamplugh collection (BM. C.72641), as *S. (C.) cf. discofalcatus*. Some even smaller, closely related forms which may be the earliest whorls of *S. (C.) discofalcatus* are described below as *S. (?C.) sp. a.*

Of the Speeton specimens definitely referred to *S. (C.) discofalcatus*, one (GSM. 21493) is recorded as "B. Base" and the horizon of the others is not accurately recorded. Lamplugh's small *S. (C.) cf. discofalcatus* is from C3. The species is more common in the Tealby Limestone of Lincolnshire, where large individuals of 100–240 mm diameter occur. These closely match the typical Russian forms; a Russian specimen from Ulyanovsk (Simbirsk) (Damon collection, BM. C.5) is figured here (Pl. 11, fig. 5) for comparison.

The Speeton specimen which Pavlow (1892 : 505, pl. 18, fig. 2) figured as *S. (C.) discofalcatus* belongs to *S. (C.) gottschei* (Koenen).

DISTRIBUTION: *variabilis* zone, Speeton and Lincolnshire; *marginatus* zone (*S. (C.) cf. discofalcatus*), Speeton; *tenuis?* and *strombecki* zones, north Germany; *decheni* zone, *discofalcatus* and *umbonatus* subzones, Russia.

Simbirskites (Craspedodiscus) phillipsi (Roemer)

(Pl. 9, fig. 3)

1841 *Ammonites phillipsii* Roemer: 85.

DISCUSSION: *S. (C.) phillipsi*, was first described, though not figured, by Roemer (1841: 85), who suggested that Phillips' (1829: 123; 1835: 94) record of *Am. lamberti*? from the Speeton Clay referred to this species. Roemer described *Am. phillipsi* as involute, disc-shaped, with an almost carinate venter, and with ribs which bifurcate at a small tubercle near mid-flank, one of the pair bifurcating again later on the whorl flank. The primary ribs number 24–30 on the last whorl. The size of the specimen was not indicated, though "4–5 whorls", were recorded which suggests that it may have been fairly large. The original is now lost.

The lack of a figure or a good original definition of the species has led to considerable variation in its interpretation. Neumayr and Uhlig (1881: 33, pl. 15, fig. 7) were the first to figure the species, their figured specimen probably being smaller than Roemer's original. They state that in their figured, incomplete example, there are 24 to 30 primary ribs, which split into 2 or 3 secondaries somewhat under half-way over the whorl, occasional ribs bifurcating again later on the whorl. The venter is described as narrow and strongly rounded; the figure shows that the venter is probably more rounded than in the specimen described by Roemer, but this may be a reflection of difference in size rather than of any specific difference. Neumayr and Uhlig's specimen may well belong to Roemer's species, but unfortunately this specimen too is lost.

Weerth (1884: 17, pl. 4, figs 2, 3) next described and figured a large individual (102 mm in diameter) from the Teutoburger Wald. This agrees with Roemer's original description in density of primary ribbing (25 ribs on the last whorl) and in having a very narrow, almost keeled venter. Weerth, however, stated that about a third of the way over the whorl the primary ribs branch into three or four secondary ribs, which in turn frequently bifurcate later, whereas Roemer only recorded two secondary ribs, one of which later bifurcates.

Weerth's original is believed lost, but in the Weerth collection at Göttingen there are two Tönsburg (Teutoburger Wald) specimens (Orig. Nr. 457–124, 457–123) referred to by Koenen (1902: 157), the larger of which (Orig. Nr. 457–124) is almost identical in size, general proportions and rib-pattern to Weerth's figured specimen. This specimen is figured here (Pl. 9, fig. 3) as *S. (C.) phillipsi* (Roemer *sensu* Weerth).

DIMENSIONS:

110 (approx.); 58 (approx.), 25.8, 15.0.

It is close to *S. (C.) discofalcatus* in general proportions but has more numerous primary and secondary ribs and a slightly narrower umbilicus.

Pavlov (1901: 79) included the more inflated Speeton specimen which he had previously (1892: pl. 18, fig. 2) figured as *S. (C.) discofalcatus*, in *S. (C.) phillipsi*, and suggested that the latter differed from *S. (C.) discofalcatus* in having more numerous primary ribs and a broader venter. In fact, the descriptions reviewed

above suggest that the German forms described as *S. (C.) phillipsi* have as sharp a venter as that of *S. (C.) discofalcatus* but are more finely ribbed (25–30 primaries per whorl instead of 19–22). The Speeton form figured by Pavlow is here included in *S. (C.) gottschei* (p. 56).

In view of the difficulty surrounding the interpretation of *S. (C.) phillipsi* it is a very unsatisfactory zonal index, though Koenen (1902) and Spath (1924) both recognized a *phillipsi* zone.

Simbirskites (Craspedodiscus) sp. (phillipsi group)

(Pl. 5, fig. 2)

?1904 *Simbirskites phillipsi* (Roemer); Koenen: pl. 1, fig. 6.

MATERIAL: Three; one small whorl fragment from the base of C2B (author's collection, BM. C.75881) and latex casts from 2 external moulds on a nodule from the base of C2B (author's collection, BM. C.75882–3).

The rib-pattern of these three specimens is close to that of the German individuals described above as *S. (C.) phillipsi* (Roemer *sensu* Weerth), but because of their much smaller size they cannot definitely be referred to that species.

The inner whorls of *S. (C.) discofalcatus* and *S. (C.) variabilis* have fewer primary ribs and a higher number of secondaries per primary. *S. (C.) juddi* has a similar rib-pattern to that of *S. (C.) sp. (phillipsi group)* but has a narrower umbilicus.

The Heligoland specimen figured by Koenen (1904) as *S. phillipsi* is probably conspecific with the Speeton specimens.

***Simbirskites (Craspedodiscus) juddi* sp. nov.**

(Pl. 10, figs 1, 2)

1867 *Ammonites clypeiformis* d'Orbigny; Judd: 246.

1924 *Craspedodiscus clypeiformis* (Judd *non* d'Orbigny); Spath: 79, 87.

DIAGNOSIS: A compressed, involute, oxycone *Craspedodiscus* with very narrow umbilicus, acute venter and fine, dense, primary and secondary ribs.

TYPE SERIES: Holotype: GSM. 31059 (Judd collection) from the Tealby Limestone of Tealby. Paratype: BM. C.73375 (J. E. Lee collection), Tealby Limestone, Normanby.

DESCRIPTION: Shell compressed, involute, oxycone, umbilicus very narrow. Ribs fine, dense, branching irregularly; primary ribs branch about half way over the flank into two or three secondaries, and additional secondaries are intercalated close to the venter. The ribs curve forwards over the acute venter.

DIMENSIONS OF FIGURED SPECIMENS:

GSM. 31059 (holotype). 153: at 145; 78, 29.5, 14.

BM. C.73375 (paratype). 107.5, 59, 27.5, 9.

DISCUSSION: The rib pattern can only be seen clearly on part of the holotype, and changes of rib-pattern with growth have not been observed. Despite the indifferent preservation of the type material, *S. (C.) juddi* is readily distinguished from *S. (C.) phillipsi* (Roemer *sensu* Weerth) and *S. (C.) discofalcatus* (Lahusen) by the greater compression of the shell and greater degree of involution with consequently narrower umbilicus. It is further distinguished from *S. (C.) discofalcatus* by its denser primary and secondary ribbing.

S. (C.) juddi was recorded by Judd (1867 : 246) as *Ammonites clypeiformis* d'Orb, and the holotype is a specimen from Tealby presented to the Geological Survey by Judd in 1867. This is almost certainly the same specimen which Pavlow (1901 : 80, footnote) referred to as close to *S. (C.) discofalcatus* but even more discoidal; Pavlow provisionally identified it as "*Ammonites discus*".

Lamplugh's (1896 : 210) reference to "*Ammonites clypeiformis*" probably embraces both *S. (C.) juddi* and *S. (C.) discofalcatus*.

Stratigraphical information on the relative position within the Tealby Limestone of *S. (C.) discofalcatus* and *S. (C.) juddi* is lacking, and Spath's (1924) recognition of a *clypeiformis* (Judd *non* d'Orb.) zone above a *discofalcatus* zone is presumably based on his suggestion (Spath 1924 : 87) that *S. (C.) clypeiformis* Judd *non* d'Orb. is the final, oxycone stage of the *Craspedodiscus* group.

DISTRIBUTION: Upper part of the *variabilis* zone, Tealby Limestone, Lincolnshire.

Simbirskites (?*Craspedodiscus*) sp. a

(Pl. 11, fig. 1)

MATERIAL: 14 septate nuclei (10 in author's collection BM. C.75862-71; 4 in Neale collection) from C3, Speeton.

DESCRIPTION: Known from septate inner whorls only; the largest specimen is only about 20 mm in diameter, and in none are details of the ribbing preserved above 15 mm diameter. Shell involute, moderately compressed, venter narrowly rounded. Primary ribs extend nearly half-way over the whorl, where they swell slightly and branch into secondaries. Three or four, sometimes five, secondaries are associated with each primary, of which two or three branch from the primary and one or two are intercalated close to the point of branching. Ribs prorsiradiate, curving strongly forwards near to and over the venter.

DIMENSIONS OF FIGURED SPECIMEN:

BM. C.75862. 13.6: 7.0, 6.1, 3.0. 19 pr. ribs.

DISCUSSION: This species is common in C3 at Speeton, from which bed Lamplugh (1889 : 596) recorded it as "the fine-ribbed variety of *Amm. speetonensis*". The specimens are too small to be identified with certainty but appear close to the earliest whorls of *S. (C.) discofalcatus* as described by Pavlow (1901 : 79). They have more numerous secondary ribs per primary than the early whorls of *S. (M.) speetonensis*.

Simbirskites (?*Craspedodiscus*) sp. b

(Pl. 6, fig. 1)

1868 *Ammonites bipinnatus* Williamson MS.; Judd: 246 (pars).

A large Tealby Limestone ammonite (GSM. 47071, presented by Judd and labelled "*Ammonites bipinnatus*") has the following dimensions:

205: at 198; 76.5, —, 62.

It is slightly involute with gently curved flanks and narrowly arched venter. Primary ribs bifurcate about a third of the way over the whorl flank, and one or both secondaries may branch again nearer the venter. Occasionally a secondary is intercalated in mid-flank. The suture has long, narrow, strongly divided saddles and lobes.

The specimen is probably an original of Judd's (1868 : 246) record of *A. bipinnatus*. However, the record of this species from the "Ancyloceras beds" of the Speeton Clay (associated with "*Ancyloceras duvalii*" in Judd's fig. 4) probably refers to *S. (C.) gottschei*, the outer whorls of which are close to the present specimen but are more evolute with shallow constrictions. The stratigraphical horizon would agree; although it is difficult to correlate the "Ancyloceras beds" with Lamplugh's succession they may correspond with bed C₄, at the base of which *S. (C.) gottschei* and *Aegocrioceras* cf. *seeleyi* (the "*A. duvalii*" of Judd's record?) occur.

Subgenus *SIMBIRSKITES SENSU STRICTO*

DIAGNOSIS: Shell inflated to coronate; short primary ribs normally end at prominent tubercles, from which arise 2–4 secondary ribs. Both types of suture occur.

DISCUSSION: *S. (S.) pavlovae* and *S. (S.) coronatiformis*, the two earliest known *Simbirskites* s.s., occur in the upper part of the Russian *versicolor* zone and it has already been suggested (p. 39) that they may be connecting links between *S. (Speetonicerias) versicolor* and later *Simbirskites* s.s. The inner whorls of both species differ from those of *S. (Sp.) versicolor* and allies in being more inflated with more numerous secondary ribs (3–4) per primary. With growth the number of secondary ribs decreases to two per primary and the whorl becomes less coronate, so that adult specimens closely resemble contemporaneous *Speetonicerias* (Chernova 1952 : 53). Thus both morphologically and stratigraphically they lie between *S. (Sp.) versicolor* with bifid ribbing and inflated inner whorls, and later *Simbirskites* s.s. which remain inflated or coronate with 3–4 secondary ribs throughout growth.

Simbirskites s.s. appears to have evolved along a separate line from the *Milanowskia*–*Craspedodiscus* groups, though evolutionary relationships are still far from clear and there may be connections between these three subgenera.

Simbirskites s.s. is rare at Speeton, being represented by a few small, septate nuclei belonging to three species; large specimens are common in Russia, and the most typical form and sculpture is seen in specimens of 50–90 mm diameter (Chernova 1952 : 47). Above this diameter the sculpture usually weakens.

***Simbirskites (Simbirskites) umbonatus* (Lahusen)**

(Pl. 12, fig. 15; Text-fig. 2k)

- 1874 *Ammonites umbonatus* Lahusen: 33, pl. 5, fig. 2; pl. 6, fig. 1 (*non* 2).
 1884 *Ammonites picteti* Weerth: 12, pl. 2, fig. 6 (?*non* fig. 5).
 1901 *Simbirskites umbonatus* (Lahusen) Pavlow: 71, pl. 5, figs 1, 2.

DISCUSSION: *S. (S.) umbonatus* is a coronate species in which strong primary ribs branch at a prominent tubercle into three or four secondaries; a Russian specimen in which each rib trifurcates is figured here, and has the following dimensions:

78·7: 28·7, 37·6, 31·7. 25 primary ribs, approx. 75 secondary ribs.

The specimen (BM. C.17, Damon collection) is from Ulyanovsk (formerly Simbirsk).

Although *S. (S.) umbonatus* is well known in Russia and is a subzonal index in the Russian *decheni* zone, it has not been found at Speeton; the specimens recorded by Pavlow (1892: 503, pl. 18 (11), figs 3, 8) belong to the less inflated *S. (S.) yorkshirensis* Chernova. The small specimens described here as *S. (S.) marginatus* (Phillips) may be the inner whorls of *S. (S.) umbonatus*; their relationship is discussed below.

***Simbirskites (Simbirskites) marginatus* (Phillips)**

(Pl. 12, figs 13, 14; Text-fig. 2i)

- 1829 *Ammonites marginatus* Phillips: 123, pl. 2, fig. 41.
 1835 *Ammonites marginatus* Phillips; Phillips: 95, pl. 2, fig. 41.
 1868 *Ammonites marginatus* Phillips; Judd: 247.
 1875 *Ammonites marginatus* Phillips; Phillips: 264, pl. 2, fig. 41.
 1889 *Ammonites marginatus* Phillips; Lamplugh: 614.
 1924 *Simbirskites marginatus* (Phillips) Spath: 77.
 1962 *Ammonites marginatus* Phillips; Howarth: 132.

TYPE: The holotype (from the Speeton Clay of Speeton), formerly believed lost (Howarth 1962: 132), is in the Yorkshire Museum, tablet 414. It is refigured here (Pl. 12, fig. 13).

MATERIAL: 12 specimens: BM. C.75872-79 (author's collection) from C3 and BM. C.75880 from C2F, Speeton. BM. C.34955-6 and YM. tablet 414A from Speeton, exact horizon not known.

DESCRIPTION: Known from early whorls (up to 15 mm diameter) only. Shell inflated, whorl-section sub-coronate to coronate. Umbilical wall bears feeble rib-folds which terminate just above the umbilical edge in prominent tubercles, 11 or 12 per whorl. From these arise four or five secondary ribs, of which one is usually intercalated. The secondaries curve gently forwards over the broad ventral region. The tubercles appear at a very early growth-stage (3·5-4·0 mm diameter) and the ribs slightly later (7 mm diameter).

The external suture (Text-fig. 2i) has relatively narrow elements, even at only 9·5 mm diameter.

DIMENSIONS OF FIGURED SPECIMENS:

YM. tablet 414 (holotype). 11·3; 5·1, 7·3, 3·6. 12 tubercles.

BM. C.75874. 12·0; 6·2, 9·4, 3·7. 12 tubercles.

DISCUSSION: Although known only from small specimens, this species is sufficiently well-marked to have long been recognized as distinctive of part of the Upper C Beds, "occurring most frequently in the lower part of the *Echinospatangus*-bed [C3], though nowhere abundant" (Lamplugh 1889 : 614). It occurs scattered throughout C3 and is a useful index fossil for this part of the succession.

S. (S.) marginatus may be conspecific with the Russian *S. (S.) umbonatus* (Lahusen), for the holotype closely matches a Russian individual of 15 mm diameter figured by Pavlow (1901 : pl. 5, fig. 2) as the early whorls of *S. (S.) umbonatus*. In the absence of larger Speeton specimens closer comparison is not possible. The comparison between the two species is further complicated by Chernova's (1951 : 55) view that Pavlow's figured specimens of *S. (S.) umbonatus* are not conspecific with Lahusen's originals. Chernova renamed Pavlow's specimens as *S. (S.) pavlovi* nom. nov., though it is doubtful whether they are really a distinct species.

S. (S.) marginatus differs from the more inflated varieties of the *S. (S.) decheni* group in having sharper tubercles and finer ribbing.

Because of the small size of the holotype and Phillips' sketchy figure, the specific name "*marginatus*" caused confusion for later workers; Roemer (1841 : 86) apparently applied it to a species of *Polyptychites*, a practice definitely followed by Neumayr and Uhlig (1881 : 157) and Koenen (1902 : 127; 1909 : 25).

DISTRIBUTION: Speeton Clay, *marginatus* zone, Speeton.

***Simbirskites (Simbirskites) yorkshirensis* Chernova**

(Pl. 12, figs 2, 5, 7)

1892 *Olcostephanus (Simbirskites) umbonatus* (Lahusen); Pavlow: 504, pl. 18 (11), figs 3, 8.

1924 *Simbirskites* aff. *toensbergensis* (Weerth); Spath: 77.

1951 *Simbirskites iorkshirensis* (sic) Chernova: 63.

TYPE: Chernova introduced *S. yorkshirensis* as a *nomen novum* for *S. (S.) umbonatus* Pavlow (1892) *non* Lahusen; of the two syntypes, the original of Pavlow's plate 18 (11) fig. 8, is here selected lectotype. BM. C.34962, from the upper C Beds, Speeton.

MATERIAL: Four small septate specimens from the Speeton Clay; BM. C.75884 (author's collection) from bed C2C, BM. C.75885-6 (author's collection) from the upper C Beds, and Wrights' collection 24284.

DESCRIPTION: Shell slightly inflated with ellipsoid whorl section, broadest near the umbilical edge; venter arched. Short, straight primary ribs extend about a third of the distance over the flank, ending in a prominent mid-lateral tubercle. There are 10-12 tubercles per whorl at diameters of 14-21 mm. Four, or rarely three, secondary ribs are associated with each tubercle, of which one is usually

intercalated while the others join the tubercle. Ribs nearly straight on the flanks, secondaries curving forwards over the venter.

DIMENSIONS OF FIGURED SPECIMENS:

Wrights' colln. 24284. 21·1; 9·6, 9·0, 6·4. 12 pr., 49 sec. ribs.

BM. C.75885. 18·7; 9·1, 8·6, 5·0. 12 pr., 46 sec. ribs.

DISCUSSION: Pavlow's other figured specimen (BM. C.34982) from the Lower Tealby Clay of Donnington-on-Bain, Lincolnshire, is considerably larger than the Speeton examples and can only provisionally be attached to *S. yorkshirensis*. Pavlow (1892 : 504) regarded his figured *S. umbonatus* as intermediate in character between *S. umbonatus* (Lahusen) and *S. toensbergensis* (Weerth), and later (1901 : 72) referred the Speeton specimens to *S. toensbergensis* instead. Three specimens of the latter species were figured by Weerth (1884 : pl. 4, figs 4–6) of which one (fig. 5) is of comparable diameter to the Speeton *S. yorkshirensis* and differs only in having slightly more numerous secondary ribs (four or five to each primary). The two are clearly closely related, but Weerth's species requires modern revision.

S. (S.) yorkshirensis differs from the inner whorls of *S. (S.) cf. decheni* in being more compressed with stronger tubercles.

DISTRIBUTION: Speeton Clay *variabilis* zone, Speeton. Lower Tealby Clay of Donnington-on-Bain, Lincolnshire (*S. (S.) cf. yorkshirensis*). *Decheni* zone, *umbonatus* subzone, Russia.

The *Simbirskites (Simbirskites) decheni* (Roemer) group

(Pl. 11, fig. 6; Pl. 12, figs 1, 3, 4, 6, 8–10)

DISCUSSION: Although *S. (S.) decheni* is a difficult species to interpret it is extensively quoted in the Russian, German and English literature and is the index fossil of the Russian *decheni* zone. The German type-specimen, from the "Quader" of the Teutoburger Wald, is lost and Roemer's (1841 : pl. 13, fig. 1) figure is poor; it is therefore difficult to decide whether two specimens from the Osning Sandstone of Tönsberg (Teutoburger Wald) figured by Weerth (1884 : pl. 1, fig. 3; pl. 2, fig. 1) are conspecific with Roemer's original. Most Russian workers have followed Pavlow's (1901) interpretation of the species, as did Wedekind (1910 : 94) in Germany. Pavlow (1901 : 69) had conserved the specific name for those Russian forms which (following Lahusen 1874) were commonly referred to *S. (S.) decheni*, whilst showing that Roemer's original description also corresponded in part to two other Russian species, *S. elatus* and *S. pseudobarboti*. Pavlow therefore attributed authorship of the Russian *S. (S.) decheni* to Lahusen.

The species clearly requires stabilization by the erection of a neotype, but this cannot be attempted until a satisfactory German specimen becomes available. The various English, German and Russian forms which have been figured as *S. (S.) decheni* are closely related and may well be conspecific. At Speeton the *S. (S.) decheni* group is represented by rare septate inner whorls which exhibit some variation in shell proportions and rib density; most can be compared closely with small specimens previously figured as *S. (S.) decheni*.

Two varieties occur in the lowest 0·61 metres (2 feet) of C6 (*concinus* subzone). At comparable growth-stages, BM. C.75887-9 (author's collection) and BM. C.75568 (collected from the C Beds by Mr. D. Ward) closely match the Speeton specimen figured by Pavlow (1892 : pl. 18, fig. 5 only; this specimen was later (Pavlow 1901 : 68) referred to *S. elatus* (Trautschold)). Four specimens are figured here (Pl. 12, figs 1, 3, 4, 10) as *S. (S.) cf. decheni* (Roemer) var. a. They show only a feeble swelling where the primary ribs branch, and differ from *S. (M.) concinnus* only in being slightly more inflated.

The second variety from low C6 (figured here, Pl. 12, figs 8, 9 as *S. (S.) cf. decheni* (Roemer) var. b) is more inflated with more clearly developed tubercles; there is a small specimen in the author's collection (BM. C.75890; pl. 12, fig. 9) and a larger individual (probably C6) in the Wrights' collection (17593; pl. 12, fig. 8).

A larger, strongly tuberculate specimen from Middle C, figured by Pavlow (1892 : pl. 18, fig. 4), is close to a German specimen from Ihme figured by Wedekind (1910 : pl. 4, fig. 1) and to another Ihme specimen figured here (Pl. 11, fig. 5) as *S. (S.) decheni* (Roemer) *sensu* Wedekind. It is also close to the Russian individuals figured by Pavlow (1901 : pl. 1, figs 4-6). Some partly crushed, coarsely ribbed whorl fragments from C4 (author's collection, BM. C.75891-2 from Bed C4I and Wrights' collection 24578-80, 24697) probably belong to the same variety or to a closely related, slightly more compressed form in the Lamplugh collection (BM. C.72632) figured here (Pl. 12, fig. 6) as *S. (S.) cf. decheni* var. c.

DIMENSIONS OF FIGURED SPECIMENS:

BM. C.75888. 14·4; 6·8, 8·0, 4·0.

BM. C.75568. 16·4; 7·5, 9·3, 4·5. 15 pr. ribs.

BM. C.75889. 16·0; 7·2, 8·6, 4·7. 15 pr. ribs.

BM. C.75887. 21·9; 10·0, 12·0, 6·7. 18 pr., approx. 50 sec. ribs.

BM. C.75890. 14·2; 7·0, 9·3, 3·0.

Wright's colln. 17593. 23·1; 9·7, 13·6, 7·9. 16 pr., approx. 52 sec. ribs.

BM. C.14419. 34·3; 13·4, 17·0, 12·3. 18 pr., approx. 42 sec. ribs.

Until more material becomes available it will be impossible to make an adequate study of the German and English forms or to ascertain the relationship between these and the forms figured by Weerth (1884) as *S. cf. inverselobatus* (Neumayr and Uhlig) and *S. nodocinctus* (Weerth).

Simbirskites (Simbirskites) cf. virgifer (Neumayr and Uhlig)

(Pl. 12, fig. 12)

cf. 1881 *Olcostephanus virgifer* Neumayr and Uhlig; 160, pl. 33, fig. 1.

DISCUSSION: A single whorl fragment (HU. Rn. 923, collected by Mr. D. Sowter) from the Lower Tealby Clay or Tealby Limestone of Nettleton is close to the holotype of *S. (S.) virgifer* in rib-pattern and general proportions. The primary ribs of the Nettleton specimen branch at a slight swelling into two secondary ribs; a third usually branches from the anterior side of the posterior rib of the original pair.

Simbirskites spp.

In addition to the species described above, there are a number of specimens in the author's collection and in museum collections which are too inadequately preserved for description; none of them can be definitely named but they indicate the presence of several otherwise unrecorded species.

A specimen from the Lower Tealby Clay of Nettleton (Wrights' collection 21711) and a similar individual from Speeton (Yorkshire Museum) appear close to *S. (M.) polivnensis* Pavlow (1901 : 77, pl. 7, figs 5-6). Several tuberculate fragments from C2C and C2E (author's collection) belong to the *yorkshirensis-toensbergensis* group, and two other whorl fragments from C2C and C2E (author's collection) appear close to Weerth's poorly known *Simbirskites arminius*.

Some very compressed nuclei from C5? (Wrights' collection) appear to be an undescribed species of *Craspedodiscus*, and C2E yields large, smooth *Craspedodiscus* fragments.

A large, indifferently preserved specimen from the Tealby Limestone of Nettleton (BM. C.74671, presented by Mr. A. Eborn) has a smooth septate outer whorl and sharply ribbed earlier whorls. The whorl section and ribbing of the penultimate whorl show that the specimen can be provisionally identified as *S. (M.) cf. progredicus* (Lahusen).

Spath (1924) recorded several species not described here. His record of *S. (Sp.) subinversum* (Pavlow) is believed to be based on A. P. Pavlow's misidentification of that species (p. 46). The originals of *S. triplicatus* Koenen from C6 and *S. progredicus* (Lahusen) from C3 and C1 have not been traced. The *S. (C.) carinatus* (Koenen) from B Base is probably a whorl fragment of *S. (C.) discofalcatus*. The records of *S. (C.) barbotanus* (Lahusen) and *S. (C.) phillipsi* (Roemer) Weerth sp. from the Tealby Limestone have not been confirmed.

V. ZONATION OF THE *Simbirskites* BEDS OF THE SPEETON CLAY

The four belemnite zones which Lamplugh (1889) distinguished in the Speeton Clay are large units and are therefore only of limited use in correlation. The replacement within the *Simbirskites* beds of *Hibolites jaculoides* by *Oxyteuthis* marks the C/B Beds boundary; the same faunal change occurs in Lincolnshire at the Lower Tealby Clay/Tealby Limestone junction (p. 35) and in north Germany within the *rarocinctum* zone.

Judd (1867) relied mainly on the ammonite sequence to subdivide the Speeton Clay, and was the first author to utilize a *Simbirskites* ("*Am. speetonensis*") as a zonal form. Unfortunately, although some of Judd's zones are easy to recognize others cannot be satisfactorily correlated with Lamplugh's better known lithological subdivisions. Pavlow (1892 : 559) later distinguished two ammonite zones in the Speeton Clay *Simbirskites* beds, a lower *S. (Sp.) subinversum* zone (C7-C6) and an upper *S. (S.) decheni*-*S. (M.) speetonensis* zone (C6-C1); he equated the former with the Russian *versicolor* zone and the latter with the *decheni* zone.

In 1924, Spath published a detailed zonation for the north-west European Lower Cretaceous, and for the Speeton succession this appeared to be a great advance on previous schemes. Unfortunately Spath's zonation is based upon a hypothetical ammonite succession, the zonal forms being drawn from both Speeton and North Germany, and some only occurring in one area or the other (cf. Casey's (1961 : 494) criticism of Spath's zonation of the Aptian and Lower Albian).

Spath's subdivision of the *Simbirskites* beds is:

Zone	Bed (Speeton)
<i>Paracrioceras rarocinctum</i>	Lower B (pars)
<i>S. (C.) clypeiforme</i>	Not represented (Tealby Limestone of Lincolnshire)
<i>S. (C.) discofalcatus</i>	
<i>S. (M.) progredicus</i>	C1-3
<i>S. (C.) phillipsi</i>	C4
<i>Spitidiscus rotula</i>	C5
<i>S. (M.) speetonensis</i>	C6
<i>Aegocrioceras capitanei</i>	C7
<i>Aegocrioceras capricornu</i>	
———— (unnamed gap)	

Of the zonal species, *Aegocrioceras capricornu* and *S. (C.) phillipsi* are difficult to interpret, while *A. capitanei* is an undescribed and indeterminate species known from a manuscript name only (Rawson 1970 : 591). Spath's record of *S. (M.) progredicus* has not been confirmed, and the relative position of the *discofalcatus* and *clypeiforme* (= *S. (C.) juddi*) zones is not known (see p. 63).

Chernova (1951 : 61) severely criticized Spath's zonation because his divisions were guided by Lamplugh's lithological divisions rather than by "the principle of detailed investigation of the group or groups of the most changeable forms (in this case the ammonites), which to us seems the basic principle of biostratigraphy" (translated from the Russian). Because Spath's zones were not based on the appearance of new species Chernova rezoned the *Simbirskites* beds of the Speeton Clay using the species ranges given by Spath, supplemented by reference to earlier published information. Her scheme, which utilises simbirskitid ammonites only, is as follows:

Zone	Bed
<i>S. (S.) yorkshirensis</i> and <i>S. (C.) discofalcatus</i>	C2—Base of Lower B
<i>S. (M.) progredicus</i>	Upper part of C4 to C3
<i>S. (M.) speetonensis</i>	Upper part of C6 to lower part of C4
<i>S. (Sp.) versicolor</i> and <i>S. (Sp.) subinversum</i>	Upper part of C8 to lower part of C6.

Although this is an improvement on Spath's scheme, the published information on the vertical distribution of the *Simbirskites* species is inaccurate, as Chernova realized, and thus her zonal boundaries are of little value. Again, most of the zonal species are extremely rare. The zonation of the equivalent beds in Germany is inadequate (p. 75) and is based mainly on crioceratitid ammonites, so that it is

impracticable to apply the German scheme to the Speeton Clay. The Russian zonation is based upon *Simbirskites*, but some of the zonal forms are not recorded from Speeton.

A new zonation for the Speeton sequence is therefore proposed here (Text-fig. 7); the only index species used by Spath or Chernova which has been retained in the new scheme is *S. (M.) speetonensis*. It must be stressed that in the beds above C6 ammonites are rare, and the proposed zonation for this part of the succession is tentative. In C6 and C7 ammonites are relatively common, so that here the zonation is more firmly established.

Although it is not apparent from Spath's (1924 : 76) faunal list, detailed collecting has shown a major change in the generic composition of the fauna at the C8/C7 boundary, i.e. at the base of the *Simbirskites* beds. The neocomitids (*Endemoceras*² and *Acanthodiscus*) and *Olcostephanus* die out at the top of C8 while the first *Simbirskites* and crioceratitids appear low in C7. Only the rare Tethyan forms *Spitidiscus* and *Hypophylloceras* cross the boundary.

BED	PAVLOW 1892	SPATH 1924	CHERNOVA 1951	ZONATION PROPOSED HERE	
LOWER B (pars)		<i>Paracrioceras rarocinctum</i>		<i>Paracrioceras rarocinctum</i>	LB 4
				— ? —	LB 5
					LB 6
C1	<i>S. decheni</i> and <i>M. speetonensis</i>	<i>M. progreddicus</i>	<i>S. yorkshirensis</i> and <i>C. discofalcatus</i>	<i>C. variabilis</i>	C1
C2					C2
C3		<i>C. phillipsi</i>	<i>M. progreddicus</i>	<i>S. marginatus</i>	C3
C4				<i>C. gottschei</i>	C4
C5		<i>Spitidiscus rotula</i>	<i>M. speetonensis</i>	<i>M. speetonensis</i> subzone	C5
C6		<i>M. speetonensis</i>		<i>M. concinnus</i> subzone	C6
C7	<i>Sp. subinversum</i>	<i>Aegocrioceras capitanei</i> <i>Aegocrioceras capricornu</i> -----	<i>Sp. versicolor</i> and <i>Sp. subinversum</i>	<i>Sp. inversum</i>	C7
C8	<i>Endemoceras regale</i> (C8 - C11)	<i>Subastieria sulcosa</i>		<i>Endemoceras regale</i> (C8 - C11)	C8

FIG. 7. Zonal schemes proposed for the *Simbirskites* beds of the Speeton Clay.

²The genus *Endemoceras* (type species *Hoplites amblygonius* Neumayr & Uhlig) was proposed by Thiermann (1963) for a group of boreal neocomitids previously included in *Lyticoceras* Hyatt. *Lyticoceras* (type species *Am. cryptoceras* d'Orb.) is regarded as a junior subjective synonym of *Leopoldia*.

The *regale* zone

INDEX SPECIES: *Endemoceras regale* (Pavlov)

The index species occurs throughout C10, C9 and C8; other species include *Acanthodiscus* spp. (C9 and C8), *Olcostephanus subfilosus* Spath (C8), *Subastieria sulcosa* (Pavlov) (C9A), *Parastieria peltocerooides* (Pavlov) (C9A, C9C) and *Spitidiscus inflatiformis* Spath (top nodule band of C8).

The *inversum* zone

INDEX SPECIES: *Simbirskites* (*Speetoniceras*) *inversum* (M. Pavlov)

The zone spans the whole of C7 and is 2.9 metres (9.5 feet) thick. The index species appears at the base of the zone, being common in bed C7H and rare in C7G. Rare *S. (Sp.) subbipliciforme* (Spath) occur in C7H and large, indeterminate *S. (Speetoniceras)* fragments in the nodule band of C7F. Small, flattened *S. (Sp.)* sp. (p. 47) occur in the pale blue clay of C7F just above the nodule band.

The heteromorph genus *Aegocrioceras* appears in abundance in C7G and from here to the top of the *inversum* zone is the dominant element of the fauna. *Crioceratites* first appears at the top of the zone, in bed C7A.

The *speetonensis* zone

INDEX SPECIES: *Simbirskites* (*Milanowskia*) *speetonensis* (Young and Bird).

ZONE		INVERSUM					SPEETON- ENSIS		GOTTSCHKEI					MARGINATUS				VARIABILIS						
BED		C7H	C7G	C7F	C7E	C7D -A	C6 lower	C5L upper -A	C4L	C4K	C4J	C4I	C4H -A	C3	C2F	C2E	C2D	C2C	C2B	C2A	C1B	C1A	LB6	LB5E
SPECIES																								
<i>Sp. subbipliciforme</i>		x																						
<i>Sp. inversum</i>		x	x																					
<i>Sp. sp.</i>				x																				
<i>Spindel</i>				x																				
<i>M. concinnus</i>							x																	
<i>M. staffi</i>							x																	
<i>M. speetonensis</i>								x																
<i>M.cf. lippiacus</i>															x									
<i>C. gottschei</i>									x															
<i>C. sp. o</i>														x										
<i>C. variabilis</i>																	x	x					x	
<i>C. sp (phillipsi group)</i>																			x					
<i>C. discofalcatus</i>																							x	
<i>S. decheni group</i>							x					x												
<i>S. marginalus</i>														x	x									
<i>S. yorkshirensis</i>																	x							

FIG. 8. Distribution of species of *Simbirskites* in the Speeton Clay.

Includes beds C6 and C5, and is approximately 12.9 metres (42.2 feet) thick.

Both Spath (1924) and Chernova (1951) recognized a *speetonensis* zone, though with different upper and lower limits (Text-fig. 7).

The base of the zone is drawn at the base of C6, where there is an important change in the ammonite fauna. The abundant *Aegocrioceras* of the *inversum* zone die out, and there is a change in the subgeneric composition of the *Simbirskites* fauna, species of *Milanowskia* and *Simbirskites* s.s. replacing *Speetonicer*as. From this level upward *Simbirskites* becomes the dominant ammonite of the C Beds fauna. Two subzones are recognized, a *concinus* subzone below and a *speetonensis* subzone above, *S. (M.) concinns* being limited to the lower part of C6 and *S. (M.) speetonensis* to the upper. C5 has not yielded identifiable *Simbirskites* and can only provisionally be included in the *speetonensis* subzone.

Fragments of septate inner whorls of the *Crioceratites beani* group occur in the *concinus* subzone and *S. (M.) staffi* and *S. (S.)* cf. *decheni* in the basal part of the subzone. Rare *Spitidiscus rotula* (Sowerby) occur in bed C5L (*speetonensis* subzone).

The *gottschei* zone

INDEX SPECIES: *Simbirskites (Craspedodiscus) gottschei* (Koenen).

Includes all the subdivisions of bed C4, and is approximately 9.5 metres (31.2 feet) thick. The index species occurs in the basal bed, C4L, and from this level upward *Simbirskites* occurs spasmodically through the rest of the C Beds and extends into the base of Lower B. Large *Aegocrioceras* cf. *seeleyi* (Neumayr and Uhlig) are associated with *S. (C.) gottschei* in C4L. Although *Simbirskites* is rare higher in C4, crushed *S.* cf. *decheni* occur in C4I (p. 68) and large, flattened *Simbirskites* of the *kleini* group have been seen high in C4.

The *marginatus* zone

INDEX SPECIES: *Simbirskites (Simbirskites) marginatus* (Phillips).

The zone includes bed C3 and beds C2F–C2D, and is 3.6 metres (11.8 feet) thick. The index species occurs throughout C3, appearing at the very base of this bed, and a single specimen is known from C2F. Associated with it in C3 are the small specimens described above (p. 63) as *S. (C?)* sp. a. Beds C2D and C2E are provisionally included in this zone: C2E yields *S. (M.)* cf. *lippiacus* (Weerth) and indeterminate fragments of the *yorkshiresis-toensbergensis* group (p. 69), together with poorly preserved fragments of a large, indeterminate *Simbirskites* with smooth outer whorls (p. 69).

The *variabilis* zone

INDEX SPECIES: *Simbirskites (Craspedodiscus) variabilis* sp. nov.

The base of the zone is drawn at the base of C2C where the index species first appears. *S. (C.) variabilis* is the commonest ammonite of the zone, occurring in C2C, the nodules at the base of C2B, and in LB6. Rare *S. (S.) yorkshiresis* Chernova and *Paracrioceras statheri* Spath occur in C2C and *S. (C.)* sp. (*phillipsi* group) (p. 62) in the nodules at the base of C2B. Some larger whorl fragments of

the *yorkshirensis-toensbergensis* group occur in C2C. A single *S. (C.) discofalcatus* is recorded from LB6 and two indeterminate *Simbirskites* nuclei have been found in LB5E. *S. (C.) discofalcatus*, *S. (C.) juddi* and *S. (?C.)* sp. b occur in the Tealby Limestone of Lincolnshire, which is correlated with the upper part of the *variabilis* zone.

The *rarocinctum* and *fissicostatum* zones

Ammonites are rare above Bed LB6 and the only common forms are large, crushed and indeterminate crioceratitids which usually decompose on exposure. The few determinable specimens are conspecific with German forms and the German zonal divisions can provisionally be adopted for this part of the Speeton succession. Kaye (1964 : 349) recorded *Paracrioceras strombecki* from Bed LB3 and considered it likely that beds LB4-6 were also of *strombecki* zone age. Kaye's record is doubtful; the occurrence of *S. (C.) discofalcatus* in the German *strombecki* zone (p. 76) suggests that this zone should be equated with part of the *Simbirskites* beds (Text-fig. 9). My own collecting has yielded several fragmentary *Hoplocrioceras fissicostatum* (Roemer *sensu* Neumayr and Uhlig) in Bed LB3, thus equating this part of the succession with the German *fissicostatum* zone. Beds LB4-LB5D are provisionally included in the *rarocinctum* zone, though identifiable ammonites have not yet been found here.

VI. CORRELATION WITH OTHER AREAS

(a) North Germany

The marine Lower Cretaceous strata of the Lower Saxony Basin overly non-marine Wealden Beds; invasion of the sea commenced early in the Lower Valanginian (German "Mittel Valendis"). From then to the upper Cretaceous there was continuous deposition of sediments, dark grey, often shaley clays with bands of ferruginous concretions being laid down in the central part of the basin while shallower-water, marginal facies beds were deposited along the extremities (Thiermann and Arnold 1964 : 692). Sandstones, usually interdigitating with clays, occur around the south-western margin (Bentheim embayment: Kemper 1963) and along the Teutoburger Wald and Eggegebirge. Further east, fringing the northern foothills of the Hartz, occur the important iron ores of the Saltzgitter region.

Simbirskites is well represented in German museum collections though there are few localities from which it can still be collected. The large specimens figured by Neumayr and Uhlig (1881) came from the ironstones of Saltzgitter while the fauna described by Weerth (1884) was collected from the sparsely fossiliferous Osning Sandstone of the Detmold region (Teutoburger Wald). The most prolific collecting locality was the brick-pit at Ihme, 8 kilometres south-west of Hannover (Wedekind 1910). The best modern section is the Moorberg brick-pit at Sarstedt, 17 kilometres south-south-east of Hannover, where the Hauterivian and Barremian are well exposed. Here the clays were deposited in relatively shallow water in the region of a salt stock. They are lighter in colour and less shaley than their equivalents in the central region of the Lower Saxony Basin, but are lithologically very similar to the equivalent horizons at Speeton.

The *Simbirskites* described by Neumayr and Uhlig (1881) and Weerth (1884) have remained difficult to interpret, and few species were figured in Koenen's (1902) monograph on the north German Lower Cretaceous ammonites. The latter author did, however, describe numerous crioceratitid species from the later Hauterivian and early Barremian strata, and the zonal schemes for this part of the German Lower Cretaceous have consequently relied largely on crioceratitids (e.g. Koenen 1902; Stolley 1925). The zonation currently in general use (e.g. Bartenstein and Bettenstaedt 1962; Bähr, unpublished dissertation) is summarized in Text-fig. 9. This zonation is inadequate, for many of the zonal species are extremely rare and difficult to interpret.

The pattern of ammonite distribution in the later Hauterivian strata is similar to that at Speeton, in that crioceratitids become rare above the beds with abundant *Aegocrioceras* while *Simbirskites* decreases in numbers upwards but usually dominates the fauna. From Bähr's unpublished work and from my detailed collecting in the lower part of the *Simbirskites* beds at Sarstedt it is apparent that the *Simbirskites* zones proposed here for the Speeton succession could usefully be adopted, with modification to allow for local variation, for the north German succession. Many of the species ranges discussed below have been obtained from Bähr's unpublished dissertation.

The *capricornu* zone

INDEX SPECIES: *Aegocrioceras capricornu* (Roemer).

The *capricornu* zone overlies the *Endemoceras noricum* zone, the fauna of the *regale* zone of Speeton and the *Speetonicer* fauna of the base of the *inversum* zone being unrepresented in north Germany. This is believed to be due to a failure in preservation rather than to a stratigraphical break.

Aegocrioceras is abundant in the lower part of the *capricornu* zone, and rare body chamber fragments of large *Crioceratites* of the *wermbleri* group appear in the middle of the zone (author's collection, from Sarstedt). Abundant *Simbirskites* appear a few centimetres above this level and almost completely replace *Aegocrioceras*. Exactly the same faunal sequence is seen at Speeton, where *Aegocrioceras* is abundant through most of the *inversum* zone (C7), is joined by *Crioceratites* cf. *wermbleri* (Koenen) in the top bed of the zone (C7A) and is replaced by abundant *Simbirskites* a few centimetres higher in the succession, at the base of the *speetonensis* zone (base C6). The same species, *S. (M.) concinnus*, *S. (M.) staffi* and *S. (S.)* cf. *decheni*, appear in both areas, replacing identical *Aegocrioceras* assemblages, but there is a significant difference in the relative abundance of the *Simbirskites* species; at Speeton *S. (M.) concinnus* is common and *S. (M.) staffi* extremely rare, while the inverse relationship holds in Germany.

The *hildesiense* zone

INDEX SPECIES: *Crioceratites hildesiense* (Koenen).

The index species is rare; its first appearance defines the base of the zone. *S. (M.) staffi* extends into the lower part of the zone and *S. (S.)* of the *decheni* group occur

throughout. The zone can be correlated with some part of the *speetonensis* zone of Speeton.

The *seeleyi* zone

INDEX SPECIES: *Aegocrioceras seeleyi* (Neumayr and Uhlig)

A. seeleyi is common at the base of the zone (Bähr, unpublished dissertation); about 2 metres above the base in the southern part of the Moorberg pit, Sarstedt, there is a rich *Simbirskites* horizon, from which I have collected numerous septate inner whorls of an undescribed species (= *S. sp. nov.* of Wedekind (1910 : pl. 4, fig. 2) and *S. ihmensis* Bähr MS.), a form close to *S. speetonensis* (= *S. speetonensis venustus* of Bähr) and *S. decheni* (Roemer) *sensu* Wedekind. None of the species can be matched exactly with any well-localized Speeton forms (a single *S. decheni sensu* Wedekind is known from "Middle C" (p. 68)) but the assemblage probably correlates with the higher part of the *speetonensis* zone.

S. (C.) gottschei appears higher in the *seeleyi* zone; this is found associated with *A. cf. seeleyi* at the base of the *gottschei* zone at Speeton.

Bähr also recorded *S. virgifer* (Neumayr and Uhlig) and *S. paucilobus* Koenen from the *seeleyi* zone; neither species is recorded from Speeton though *S. cf. virgifer* occurs at Nettleton.

The *tenuis* zone

INDEX SPECIES: *Simbirskites (Craspedodiscus) tenuis* Koenen.

The only German zone defined by a *simbirskitid* is based on a very rare species originally described from about 6 specimens; Bähr did not find a single specimen and was unable to separate the *tenuis* from the underlying *seeleyi* zone. *S. (C.) discofalcatus* first appears at about this level.

The *strombecki* zone

INDEX SPECIES: *Paracrioceras strombecki* (Koenen).

The index species is not common, and according to Bähr it extends up into the lower part of the *fissicostatum* zone. *Simbirskites* is rare, but *S. (C.) discofalcatus* occurs.

The *rarocinctum* zone

INDEX SPECIES: *Paracrioceras rarocinctum* (Koenen).

The zonal species is very rare and *Simbirskites* was not recorded by Bähr. The belemnite *Oxyteuthis*, typical of the Speeton B Beds, is first recorded from this zone.

The *fissicostatum* zone

INDEX SPECIES: *Hoplocrioceras fissicostatum* (Roemer).

The index species is difficult to interpret (compare the considerably different figures in Neumayr and Uhlig 1881 : pl. 56, fig. 1, and Koenen 1902 : pl. 22, figs 1,

2) but is recorded from Sarstedt by Bähr; *H. fissicostatum* (Roemer *sensu* Neumayr and Uhlig) occurs in LB₃ at Speeton.

The correlation between Speeton and north Germany suggested by these records is summarized in Text-fig. 9; much of the correlation can only be regarded as tentative, pending further detailed collecting in both areas.

Lower Cretaceous clays with *Simbirskites* occur off the coast of Heligoland, and specimens picked up off the beach were described by Koenen (1904).

(b) *Russia*

Thick, sandy clays of Hauterivian and Barremian age are widespread through the middle Volga region and the Moscow syncline. They have been divided into the Simbirskitid Beds below and the Belemnite Series above, the former yielding an extensive *Simbirskites* fauna and the latter a belemnite-lamellibranch fauna. Early work on the Simbirskitid Beds culminated in Pavlov's (1901) extensive review of the stratigraphy and *Simbirskites* fauna. The Simbirskitid Beds were divided into a *versicolor* zone below and a *decheni* zone above, each of which has subsequently (Chernova 1951) been divided into three subzones. Chernova reviewed earlier

SPEETON		GERMANY	RUSSIA		TETHYS	STAGE	
LB 3	<i>fissicostatum</i>	<i>fissicostatum</i>	SUBZONE	ZONE		B A R R E M I A N	
— ? —			BELEMNITE SERIES with <i>Oxyteuthis brunsvicensis</i> (pars)				
LB 4 - LB 50	<i>rarocinctum</i> (no ammonites recorded)	<i>rarocinctum</i>					
— ? —						(pars)	
LB 5E - C 2C	<i>variabilis</i>	— ? — <i>strombecki</i>	<i>umbonatus</i>	<i>decheni</i>	<i>angulicostata</i>	H A U T E R I V I A N	
C 2D - C 3	<i>marginatus</i>	— ? — <i>tenuis</i>					<i>discofalcatus</i>
C 4	<i>gottschei</i>	— ? — <i>seeleyi</i>					— ? —
C 5 - C 6	<i>speetonensis</i>	— ? — <i>hildesiense</i> — ? —	<i>speelonensis</i>				<i>sayni</i>
C 7	<i>inversum</i>	<i>capricornu</i>	<i>pavlovae</i> — ? — <i>inversum</i>	<i>versicolor</i>	<i>duvalii</i>	(pars)	
C 8 - C 11	<i>regale</i>	FAUNAL BREAK	<i>versicolor</i> — ? —				— ? — <i>radiatus</i> (pars)
			NO DEPOSITS				

FIG. 9. Comparison between the Speeton zones and their German, Russian and Tethyan equivalents. ? indicates that the correlation with the Speeton zones is only approximate.

evidence showing that the *Endemoceras* fauna of the earliest Hauterivian beds of western Europe is absent over most of Russia, the Simbirskitid Beds resting on an eroded Valanginian surface in the Middle Volga region and transgressing over various horizons of the Valanginian or late Jurassic in the Moscow syncline.

The classic sequence in the Simbirskitid Beds and Belemnite Series is a 7 km section along the right bank of the Volga, from the village of Polivny to Ulyanovsk (formerly Simbirsk). Here, Chernova (1951 : 52-55) recognized the following faunal sequence in the Simbirskitid Beds:

The *versicolor* zone

The zone is typified by species of the subgenus *Speetoniceras*, which dies out at the top of the zone.

a. *versicolor* subzone

S. (Sp.) versicolor occurs sporadically in the lower part of the subzone and becomes abundant higher up, where *S. (Sp.) subinversum* and *S. (S.) coronatiformis* appear.

b. *inversum* subzone

The species of the *versicolor* subzone are joined by *S. (Sp.) inversum*.

c. *pavlovae* subzone

In the lower part of the subzone the species of the *inversum* subzone still occur, together with *S. pavlovae* Chernova (*nomen novum* for *S. elatus* M. Pavlow non Trautschold). In the upper part of the subzone *S. (S.) coronatiformis* disappears and *S. (Sp.) versicolor* and *S. (Sp.) inversum* are rare.

The *decheni* zone

a. *speetonensis* subzone

The base of the subzone is marked by a major faunal break; all the species of the *versicolor* zone disappear and are replaced by species of the subgenera *Simbirskites* s.s., *Milanowskia* and *Craspedodiscus*.

b. *discofalcatus* subzone

Most species of the *speetonensis* subzone disappear but the subzone is characterized by large numbers of *S. (C.) discofalcatus*, *S. (M.) progredicus*, *S. (M.) polivnensis*, *S. (S.) umbonatiformis* and *S. (S.) pseudobarboti*.

c. *umbonatus* subzone

Characterized by *S. (S.) umbonatus* and *S. (S.) pavlovi* Chernova (*nomen novum* for *S. umbonatus* Pavlow 1901 non Lahusen). Ammonites are restricted to the lower part of the subzone.

The distribution of *Simbirskites* in the Ulyanovsk section is summarized in Text-fig. 10, compiled from Chernova's (1951 : table 5; pp. 52-55) published work.

The boundary between the *versicolor* and *decheni* zones correlates with the *inversum/speetonensis* zonal boundary at Speeton. The Russian *inversum* subzone is represented in the lower part of the Speeton Clay *inversum* zone while the *pavlovae*

subzone probably correlates with the upper part of the zone. The relative position of the Russian *versicolor* subzone is more difficult to decide; there is either a faunal break at this level at Speeton (i.e. between the *regale* and *inversum* zones) or the *versicolor* subzone is represented by part of the *regale* zone. The latter is regarded as more likely (Text-fig. 9); *Speetonicerias* probably arose in the northern seas and migrated into the Speeton seas at a later date, replacing the neocomitid fauna.

The Russian *decheni* zone is equated with the *speetonensis* to *variabilis* zones, but

SPECIES	ZONE	VERSICOLOR			DECHENI		
	SUBZONE	VERSI-COLOR	INVER-SUM	PAVL-OVAE	SPEET-ONENSIS	DISCOF-ALCATUS	UMBON-ATUS
<i>Sp. versicolor</i>		x	x	x			
<i>Sp. subinversum</i>		x	x	x			
<i>Sp. coronatiformis</i>		x	x	x			
<i>Sp. inversum</i>		-	x	x			
<i>S. pavlovae</i>		-	-	x			
<i>C. phillipsi</i>		-	-	-	x	x	
<i>C. gottschei</i>		-	-	-	x	x	
<i>C. barboti</i>		-	-	-	x	x	x
<i>M. speetonensis</i>		-	-	-	x		
<i>M. concinnus</i>		-	-	-	x		
<i>M. lahusei</i>		-	-	-	x		
<i>S. elatus</i>		-	-	-	x		
<i>S. decheni</i>		-	-	-	x	x	
<i>S. kowalewskii</i>		-	-	-	x		
<i>C. discofalcatus</i>		-	-	-	-	x	x
<i>M. progredicus</i>		-	-	-	-	x	x
<i>M. polivnensis</i>		-	-	-	-	x	
<i>S. umbonatiformis</i>		-	-	-	-	x	
<i>S. pseudobarboti</i>		-	-	-	-	x	
<i>S. umbonatus</i>		-	-	-	-	-	x
<i>S. yorkshirensis</i>		-	-	-	-	-	x
<i>S. pavlovi</i>		-	-	-	-	-	x

FIG. 10. Distribution of species of *Simbirskites* in the Ulyanovsk (= Simbirsk) section (after Chernova 1951).

the relative position of the higher two subzones of the *decheni* zone is more difficult to establish. At this horizon there are few species in common between the two areas, though this difference may be more apparent than real, the probable similarity between the two faunas being obscured by taxonomic separation due to size differences between the large Russian forms and the small, rare Speeton individuals.

The *umbonatus* subzone is equated with the *marginatus* and *variabilis* zones at Speeton; *S. (S.) yorkshirensis* and *S. (C.) discofalcatus* are common to both areas, while the Speeton *S. (S.) marginatus* is close to (and possibly conspecific with) *S. (S.) umbonatus* and *S. (S.) pavlowi*.

This implies that the Russian *discofalcatus* subzone should be correlated with the upper part of the *gottschei* zone, i.e. with upper C4. However, *S. (C.) discofalcatus* occurs only at a much higher horizon in England—at the base of Lower B and in the Tealby Limestone of north Lincolnshire. A single, crushed *S. (C.)* cf. *discofalcatus* (Pl. II, fig. 3) is known from C3 at Speeton, and this earlier record will be strengthened if the nuclei described here as *S. (?C.)* sp. a do eventually prove to be the earliest whorls of *S. (C.) discofalcatus*. On the other hand, *S. (C.) gottschei* occurs in the *discofalcatus* subzone in Russia. In Germany, *S. (C.) discofalcatus* probably occurs in both the *tenuis* and *strombecki* zones, and thus has a similar range to the Russian forms. If the correlations outlined above are correct, then *S. (C.) discofalcatus* should also occur in upper C4 at Speeton.

VII. THE HAUTERIVIAN-BARREMIAN BOUNDARY IN NORTH-WEST EUROPE

Faunal separation in the European Lower Cretaceous reached its peak in Hauterivian and Barremian times, the ammonite faunas of the Boreal and Tethyan Provinces being almost mutually exclusive. *Simbirskites* and, in Germany and England, crioceratitids dominated the Boreal seas during late Lower Hauterivian and Upper Hauterivian times; *Simbirskites* is represented in southern Europe by only a few stray specimens, and the Tethyan crioceratitids are specifically distinct from northern forms.

Hence direct correlation between the two provinces can only be attempted on evidence from the northern Caucasus and Crimea, where elements of the two faunas intermingle. Chernova (1951), after discussing evidence from earlier Russian works (especially Karakasch 1907), concluded that the two *Simbirskites* zones recognized in the Simbirskitid Beds of the Volga Region can be traced over the Crimea and Northern Caucasus. She equated the lower, *versicolor* zone with the *Crioceratites duvali* zone of Tethys, and the upper, *decheni* zone with the Tethyan *Subsajnella sayni* and *Pseudothurmannia angulicostata* zones. Subsequent work by Drushchitz and Kudryavtseva (1960) supports this correlation.

Chernova followed Haug (1910) in drawing the Hauterivian/Barremian boundary at the base of the *sayni* zone of the standard Tethyan sequence, and hence included

the Russian *decheni* zone in the Barremian, a practice independently followed by other Russian workers. It is this which accounts for the records in Russian literature of *Simbirskites* in the Barremian. The Lyons Colloquium (Rat 1963 : Debelmas and Thieuloy 1965: Busnardo 1965) recommends that Kilian's (1910) interpretation be followed, in which the *sayni* and *angulicostata* zones are included in the Hauterivian, and the base of the Barremian is drawn at the base of the overlying *Nicklesia pulchella* zone. In Russia, Drushchitz (1962, 1964) now follows Kilian's scheme, and therefore includes the *decheni* zone in the Hauterivian. Following this correlation, the Speeton equivalents of the *decheni* zone, i.e. the *speetonensis-variabilis* zones (beds C6-LB5E) should be included in the Hauterivian, and the Hauterivian/Barremian boundary is provisionally drawn between the *variabilis* and *rarocinctum* zones. Chernova (1951 : 66) equated the top of the *decheni* zone with the *rarocinctum* or possible *fissicostatum* zone of north Germany, and Bähr provisionally drew the Hauterivian/Barremian boundary through the German *rarocinctum* zone. The same boundary is adopted here (Text-fig. 9) though German workers have customarily drawn it lower, at the base of the *strombecki* zone.

At present, the base of the Barremian in England and Germany cannot be more accurately defined; the Barremian ammonite faunas of north-west Europe consist almost exclusively of crioceratitids, specifically distinct from the rich crioceratitid faunas of the Tethyan Barremian (Sarkar 1955: Thomel 1964). In the Caucasus and Crimea the Lower Barremian faunas are essentially Tethyan, though in the Nalchik sequence of the Caucasus *Paracrioceras denckmanni* (Koenen) is recorded in association with *Costidiscus recticostatus* and other Lower Barremian Tethyan ammonites, overlying beds with *Pseudothurmannia angulicostata* and *Simbirskites* (*Craspedodiscus*) spp. (Chernova 1951 : 74). If the identification is correct it provides a useful cross-check, for *P. denckmanni* is the index fossil for the zone above the *fissicostatum* zone in north Germany.

Thus all the available evidence shows that *Simbirskites*, the last representative of the Perisphinctaceae, is a useful zonal form in the north European Hauterivian and dies out at the end of the Hauterivian.

VIII. ZUSAMMENFASSUNG

Die Ammonitengattung *Simbirskites* charakterisiert Schichten des Hauteriviums der borealen Provinz und stellt brauchbare Zonen-Leitfossilien in Rußland, Norddeutschland und NE-England. Sie tritt in England in der C7-LB5-Folge des Speeton Tons (Yorkshire) sowie im Unteren Tealby Ton und im Tealby Kalkstein (Lincolnshire) auf. Die Stratigraphie dieser Schichtenfolge wird hier erläutert. Dabei werden 21 *Simbirskites*-Arten beschrieben. Zwei davon sind neu: *S. (C.) juddi* und *S. (C.) variabilis*. Vierzehn werden bekannten Arten zugeordnet oder mit ihnen verglichen und fünf in offener Nomenklatur behandelt. Einige der Arten wurden zuerst aus Rußland oder Norddeutschland beschrieben. Von den deutschen Arten werden Topotypen des nur wenig bekannten *S. (M.) lippiacus*

(Weerth) aus dem Osningsandstein vom Tönsberg abgebildet. Ferner wird die problematische Interpretation von *S. (C.) phillipsi* (Roemer) und *S. (S.) decheni* (Roemer) ausführlich diskutiert.

Als Ergebnis einer sorgfältigen, horizontierten Absammlung der Speeton-Folge ist eine Unterteilung der Simbirskiten-Schichten in Yorkshire nach *Simbirskites*-Arten in fünf Zonen möglich. Weiterhin erlaubt die bei Speeton ermittelte Faunenfolge einen detaillierten Vergleich dieser Schichten mit den entsprechenden Ablagerungen in Norddeutschland und Rußland. Der in Norddeutschland zur Zeit üblichen Zonengliederung, die auf Arbeiten von Koenen und Stolley zurückgeht, liegen in erster Linie crioceratitische Ammoniten zu Grunde. Die meisten dieser vermeintlichen Zonenleitfossilien sind aber sehr selten. Vertreter der Gattung *Simbirskites* sind dagegen häufiger, so daß es empfehlenswert erscheint, *Simbirskites*-Arten als Leitfossilien auch in Norddeutschland heranzuziehen. Vermutlich kann die bei Speeton ermittelte Gliederung mit geringen Einschränkungen auch in Norddeutschland verwendet werden. Die russischen Simbirskiten-Schichten sind in eine Serie von Zonen und Subzonen gegliedert worden (Pavlow 1901, Chernova 1951), die enge Vergleiche mit der Schichtenfolge Yorkshires gestatten.

Das Auftreten von gemischten Faunen aus borealen und Tethys-Elementen im Nordkaukasus und auf der Krim erlaubt die Anknüpfung der borealen Zonenfolge an die Standard-Gliederung des Hauteriviums im Tethys-Raum (Text-fig. 9). Dabei ergibt sich, daß die Grenze Hauterivium/Barremium innerhalb der *rarocinctum*-Zone Norddeutschlands (Bähr, unveröffentlichte Dissertation) und an der Basis der *rarocinctum*-Zone von Speeton verläuft.

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ADDENDUM

Since this paper was written, two points have been drawn to my attention. In June 1970 Dr. Kemper informed me that renewed search at Detmold, by members of the Geologisches Landesamt Nordrhein-Westfalen, has successfully resulted in the discovery of Weerth's collection, hitherto believed lost. Dr. Kemper has subsequently (on 10 November 1970) seen the collection and recognized several type specimens of *Simbirskites*, though the majority appear to be lost. The collection does, however, include other specimens which were apparently collected after Weerth's paper was published in 1884.

In a recent paper by Hiltermann and Kemper (1969) the occurrence of *Simbirskites* in the Heligoland Hauterivian is reviewed. Four species are figured: *Simbirskites* (*Speetonicerias*) *versicolor* (Trautschold), *S. (Sp.) cf. inversum* (M. Pavlow), *S. (Cras-*

pedodiscus) juv. sp., and *S. (C.) carinatus* Koenen. The two figured *Speetonicer* closely resemble Speeton examples of the same species. The figured *S. (C.) carinatus* are similar in lateral view to the Speeton form which I figure (Pl. 5, fig. 2) as *S. (C.)* sp. (*phillipsi* group). Hiltermann and Kemper (p. 22, footnote) consider it possible that *S. (C.) carinatus* could be the juvenile stage of *S. (C.) phillipsi* (Roemer).